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ABSTRACT

The purpose of this study was to determine the relative effectiveness of two laboratory approaches in a general education physical science course: (1) the experimental method called the contemporary topics, and (2) the control method called the standard topics. The criterion instruments were an investigator-constructed subject content test, the Science Process Inventory, Form D, and the Science Attitude Inventory. The subjects were 86 students enrolled in physics at Kutztown State College, 41 assigned to the control treatment standard topics approach, 45 to the experimental contemporary topics approach. A student perception questionnaire was applied to monitor whether treatments were applied as prescribed. Using analysis of covariance, it was found that at the .01 level for the three tests, there were no significant differences, but there was a significant difference in the results of the treatment monitoring questionnaire. Findings of this study implied that there was no difference in learning facts and principles of the subject content, but other criteria, such as cost and student or faculty interest, should be used to decide between the two approaches. (JN)

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The Pennsylvania State University

The Graduate School

Department of Education

A Comparative Study of Two Laboratory Approaches in a General Education College Physical Science Course

A Thesis in

Higher Education

by

John Patrick Schellenberg

Submitted in Partial Fulfillment
of the Requirements
for the degree of

Doctor of Education

August 1980

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ABSTRACT

The primary purpose of this study was to determine the relative effectiveness of two laboratory approaches in a general education physical science course. The two approaches were: (1) the experimental method called the contemporary topics approach and (2) the control method called the standard topics approach. The determination of effectiveness was based on achievement of science facts and principles of physical science, understanding the nature of science, and scientific attitude. The criterion instruments were an investigator-constructed subject content test, the Science Process Inventory (SPI), Form D, developed by Wayne Welch, and the Science Attitude Inventory (SAI) developed by Richard Moore.

The experiment was conducted at Kutztown State College, Kutztown, Pennsylvania. The treatments were piloted during the Spring and Fall semesters of 1977. The initial and principal experimental trial was conducted during the Spring semester of 1978. A second trial was conducted during the Fall of 1978 and Spring of 1979 semesters. Eighty-six students enrolled in Physics 010 during the Spring of 1978 comprised the principal experimental sample group. Forty-one students were assigned the control treatment standard topics approach. Forty-five students were assigned the experimental contemporary topics approach. The investigator taught the common lecture but was not involved in the treatment laboratory approaches.

All three criterion instruments were administered at the beginning of the term and again at the end of the treatment period. Analysis of covariance was used to ascertain whether significant differences had occurred from pretests to posttests between the control and experimental groups. A student perception questionnaire was applied to monitor whether

the treatments were applied as prescribed.

The statistical analysis showed that at the .01 level of significance: (1) there is no significant difference in the achievement of facts and principles of physical science as measured by the investigator-constructed subject content test between the standard topics and the contemporary topics approaches; (2) there is no significant difference in the understanding of the nature of science as measured by the SPI between the standard topics and the contemporary topics approaches; and (3) there is no significant difference in the scientific attitude as measured by the SAI between the standard topics and the contemporary topics approaches.

The results were the same during both the initial experimental trial and a subsequent trial. However, the investigator found a significant difference in the results of the treatment monitoring questionnaire between the two trials. During the initial trial the monitoring results indicated complaince with prescribed treatments. During the subsequent trial the monitoring results indicated that two laboratory sections were not treated as prescribed.

Several conclusions were drawn from the findings of this study. Students achieve equally well in learning the facts and principles of the subject content, understanding the nature of science, and scientific attitude from both the contemporary topics and standard topics laboratory approaches within an eight-week or fifteen-week treatment period. This conclusion implies that other criteria such as cost and student or faculty interest should be used to decide between the two approaches. Also it is implied that the limited effect of the laboratory period may not be sufficient to provide measurable differences in the criterion variables. This study was very concerned with the monitoring of the treatments and

the results indicated that treatment monitoring can be achieved by a simple external instrument.

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CHAPTER I

INTRODUCTION

Topics of Concern to This Study

The general education program of many colleges includes courses that are intended to provide knowledge and skills that will be useful in the student's contemporary and future activities. There is a particularly evident concern for the knowledge and understanding of science by the nonscience major. Special courses have been developed to develop the scientific literacy of nonscientists (Harvard, 1945; Raines, 1974; National Science Foundation, 1975).

A laboratory course in the Physical Sciences is very often included as a general education course for nonscience majors. This investigation evaluated two laboratory approaches used in an introductory course in Physical Science to the extent that they meet the general education objectives of the nonscience major.

The instructional strategy was designed so that a common lecture presented the subject content to all students in the sample. The treatment was applied in two different laboratory approaches. The laboratory approaches were (1) an experimental treatment (CT) which includes eight weeks of reading contemporary topics from nontechnical articles and seven related experiments and (2) a control treatment (ST) which includes eight weeks or reading standard topics from reference texts and seven related experiments. (The various treatments are described in more detail in Chapter III).

To understand the context of this study it was necessary to explore the concepts of general education, scientific literacy and science for majors and non-majors.

General Education

The Harvard Report of 1945 contributes greatly to the understanding of the general education movement in the United States. It states that while the term general education is

> somewhat vague and colorless, it does not mean some airy education in knowledge in general (if there is such knowledge), nor does it mean education for all in the sense of universal education. It is used to indicate that part of a student's whole education which looks first of all to his life as a responsible human being and citizen. The term specialized education indicates that part of which looks to the student's competence in some occupation. These two sides of life are not entirely separable and it would be false to imagine education for the one as quite distinct from education for the other ... (Harvard, 1945, p. 51)

> Now, a general education is distinguished from specialized education, not by subject matter, but in terms of method and outlook, no matter what the field. (Harvard, 1945, p. 56)

It is suggested that general education be adapted

> to the needs and intentions of different groups and, so far as possible, to carry its spirit into specialized education. (Harvard, 1945, p. 58)

The report identified four abilities that should be considered in planning general education - "to think effectively, to communicate thought, to make relevant judgements and to discriminate among values" (Harvard, 1945, p. 65).

The study of science in general education is consistent with our understanding of the philosophical foundations of the prevailing forms of general education. Harold Taylor explains the philosophical foundations of the prevailing forms of general education. He details three philosophical categories: (1) Rationalism, (2) Eclecticism and Neo-Humanism and (3) Naturalism and Instrumentalism (Taylor, 1952, p. 26-41). Louis Heil states that "the procedures employed by scientists and the assumptions upon which such procedures rest are generally consistent

with instrumentalist philosophy of general education" (Heil, 1952, p. 140). He explains that the basic contribution of science to general education is that it should assist "in living a happy and purposeful life" (Heil, 1952, p. 144).

> The contribution of science and scientific thought to the problem of general education seems, therefore to be of two kinds: the use of the types of analysis and critical thinking employed in scientific activity and the application of scientific generalizations themselves, particularly as these contributions apply to meeting needs in the basic aspects of living. (Heil, 1952, p. 145)

An assumption concerning the "contribution of science and scientific thought to general education is that the kinds of analysis, thinking and procedure typically employed in scientific activity can be extended and translated in problem-solving activities in which the student should engage when endeavoring to meet their immediate and future needs" (Heil, 1952, p. 146). He also details the relationship of scientific procedure to values and ethics. The logical scientific process will assist students to determine "what constitutes consistency with experience so that he may be able to judge the acceptability of his value assumptions" (Heil, 1952, p. 147).

The references on general education cited thus far provide some basic understanding of concepts under considerable discussion and study during the period from World War II until the space race of the late 1950's. The same concepts and concerns are present in contemporary articles concerned with total education. Max Raines (1974) explains that general education and life-centered education are both located in the transactional zone of "a globe of higher education." Life-centered education is part of the utilization or pragmatic hemisphere and general education is part of the conceptualization hemisphere.

He contends that

> if you believe that the need of society and the needs of man can be and should be reconciled, you are probably concerned with a more pragmatic and life-centered emphasis which one finds in some forms of general education (Goldhammer and Taylor, 1972), which sees each basic life role as a career whether it be a family member, consumer, citizen, worker, student or culture bearer. (Raines, 1974, p. 253)

Scientific Literacy

Contemporary society is concerned with the literacy or competencies achieved through formal education. These concerns have often centered about the basic skills of verbal communication and mathematical abilities, but also there is a growing concern for the science literacy of our educated youth. Within recent years, this issue has become of sufficient importance that the National Science Foundation (NSF) has listed "science literacy" as a major program objective. The document states

> the goal is to increase substantially the number of persons who are able to make use of the methodology of science, as well as the results of scientific discovery, in their work and personal lives, whether or not they are engaged in science or technical occupations. (NSF, 1975)

Contemporary science education has three primary purposes: (1) to prepare scholars in the several disciplines of science; (2) to provide individuals with a background for technological occupations or professions; and (3) to provide individuals with a background in science as a part of their general education for effective citizenship (Agin, 1974, p. 403).

> From this last group arise the bulk of our political and economic leaders as well as the ordinary hard-working citizens. The effectiveness of these people as leaders and citizens should be the primary goal of education. Science education can help the development of more effective citizenship by (1) helping individuals to recognize their need for a better understanding of science and technology and (2) motivating them to satisfying their need for better understanding. (Agin, 1974, p. 404)

Science education should provide each individual with an understanding of science that will help his make intelligent social and political decisions. Scientific literacy is the term most frequently used to express this quest for effective citizenship via science education (Agin, 1974, p. 405).

There is a general agreement upon the objectives of science teaching and these are reflected in the three-fold aims for science teaching listed by the National Society for the Study of Education in its 59th yearbook: "First, to teach some facts and principles of science; second, to inculcate higher virtues, such as accuracy, critical thinking, scientific honesty and more generally, scientific method; and third, to develop an understanding and appreciation of science and scientists." (Pella, et al, 1966, p. 199). The National Science Teachers Association (NSTA) stated "Science teaching must result in scientifically literate citizens" (NSTA, 1964, p. 89).

In a recent article, Milton O. Pella (1976) addressed a concern that science literacy might be considered out of context. He preferred to consider "The place or function of science for a literate citizenry" (p. 97). He reflected upon the 1960's as a time "when the public was convinced of the importance of science in order to remain 'respectable' in the world; science for the sake of science was of necessity viewed differently than it seems to be at present."

He continued, "To be a functioning citizen during the current era demands that one be able to read and interpret technical literature, because his welfare or his decisions should depend on it" (Pella, 1976, p. 98). It is important to the context of this study that we note his contention that scientific literacy must be a part of a general literacy

to be of any value.

Science for Majors and Non-Majors

Physics and Chemistry courses at the college level are often offered for both majors and non-majors. Also, multidisciplinary courses called Physical Science are offered for non-majors. This study was concerned with laboratory courses of the multidisciplinary type.

The Commission on College Physics (CCP), the American Chemical Society (ACS) Curriculum Committee and the Advisory Committee on College Chemistry (AC_3) have seriously considered the development of appropriate curriculum for both majors and non-majors (Cassidy, 1972; CCP, 1964).

Courses for majors and non-majors have two principal common objectives: (1) a thorough knowledge of a coordinated selection of topics and (2) a lasting sense of understanding the topics learned (Bitter, 1960, p. 575). Majors and non-majors alike can see the "cognitive relationships connected to nature through experience... all students leave our courses with long-remembered attitudes" (Cassidy, 1972, p. 35).

John M. Fowler of the Commission on College Physics, presenting the Millikan Lecture Award, identified four objectives taken from 1959 and 1960 meetings. Science courses should (1) stimulate interest in nature and natural law, (2) familiarize students with basic principles and concepts, (3) stimulate students to accurate and meaningful thinking and (4) give them experiences that foster understanding of scientists and their abilities. He contends that courses for both majors and non-majors identify with these objectives by concern with content or process. He explains that while the objectives remain the same, the emphasis on the process objectives in more appropriate for non-majors, and content objectives are emphasized for science majors (Fowler, 1969, p. 1196-1198).

A similar separation of science education objectives into cognitive and affective classification appears in most of the literature on curriculum for majors and non-majors (ACS, 1970; Reif, 1969; Bent, 1971; CCP, 1964). The courses developed for majors or related majors focus upon the content as the primary concern and the process as implicitly related (CCP, 1964; French and Jossem, 1976). The courses developed for non-majors focus upon the affective objectives such as attitude and understanding. Non-major courses often discuss motivation as a primary concern (Cassen and Foster, 1973; ACS, 1970; Daughton, 1973; Bent, 1971).

A summary of the literature relating to science curriculum for majors and non-majors indicated that science is offered on three levels: (1) pre-professional major courses, (2) less vigorous courses for the majors in other sciences, (3) specially designed courses for non-scientists (Cassidy, 1972; CCP, 1964; French and Jossem, 1976). The first level concerns itself with the potential Ph.D. in the discipline (ACS, 1972; CCP, 1964). The second level concerns itself with interface with other sciences. Courses at this level are to concentrate on the application to other fields such as Biology, Engineering, and Medicine (CCP, 1964; French and Jossem, 1976). The third level for the non-scientist will concern itself less with content and application and more on understanding science processes and developing scientific attitudes (Cassidy, 1972 and Daughan, 1973).

The various commissions and committees, in providing a rationale for the third level, non-majors, formulate many assumptions concerning the students who take these courses. In setting objectives for the courses, consideration should be given to the needs, backgrounds and expectations

of the students (Gangemi, 1971). These students do not need the technical skills to be scientists or engineers but they do need "sufficient awareness of modern science to be free from misconceptions and better prepared to make value choices too important to be left entirely in the hands of experts" (Reif, 1969, p. 1032). The students often come to these courses with dominant feelings of "fear and apprehension" (Bent, 1971, p. 219). Included in their background is the fact that they are more concerned with people than non-living things and have selected a major consistent with their concern for interpersonal relations (Wolke, 1970; Morrison, 1964).

This study is concerned with the effectiveness of science courses designed for non-majors to provide science literacy as part of their general education. In particular, the change of scientific attitude and the change in understanding of the processes of science are to be evaluated. The concept of general education had its origins in the 1930's but became most popular during the 1940's and 1950's. More recently, the concept of science literacy has been defined and it has been shown that the need for science education for the general population is an important goal of contemporary education. Also it is important to note that a separate division of science education has been designed to meet the special needs of the non-major.

Need for the Study

In the development of this study the investigator found both a professional and a personal need for the study. The professional need focuses on the topic of science literacy while the personal need focuses on the methods used to achieve this educational objective.

Professional Need

The objectives of general education have been widely accepted by higher education. Natural Science courses are usually a component of the general education offerings.

Trent and Cohen (1973, p. 1032) inform us that there is a need for curriculum studies in higher education and Tyler (1974, p. 137) indicates a need for research in science education that will find new ways to teach students who are not now interested in science. "We need to think of science as a resource from which laymen can draw in ways that help them live their lives more meaningfully, deal with their problems more effectively and participate fully in the common life of our society" (Tyler, 1974, p. 137).

The studies of general education in science from 1938 through 1947 (Boenig, 1969) and 1948 through 1952 (Swift, 1969) concerned the following variables: course content, critical thinking ability, scientific attitudes, interest in science, problem solving and scientific method. A review of the more recent literature (ERIC, 1978) indicates that studies continue to focus on similar topics. However, a more recent term "science literacy" has been used to encompass several of the above. Scientific concepts, scientific attitude and problem solving ability are now encompassed in the term "scientific literacy" (Gibbons, 1976).

Based upon the continued concern for "science literacy" as an accept-

able education objective, it will be the purpose of this study to compare two instructional approaches to a general education physical science laboratory course.

Personal Need

For the past twelve years, the investigator has been involved in the teaching of a science course for nonscience majors. The focus of this course has been to instruct students with the concepts and principles of Chemistry and Physics. Little consideration was given to the general education purposes of the course.

The era of "steady state" within colleges has given rise to the call for increased specialization. Courses within the general education curriculum are being challenged. As an instructor of such a course, the author has been forced to scrutinize the reason for its existence. The observations were unfavorable. The course was unpopular and conceived as a hurdle to cross. Students perceived little value in such a course. The investigator's personal evaluation indicated that little attention was being devoted to the general education purposes. Faced with this dilemma, the college should either move to eliminate this course or the course should be changed to meet the needs of the students and to provide a valuable function in their general education. The investigator proceeded to develop an instructional strategy using a laboratory approach that used contemporary topics. The tests applied through the experimental design are intended to measure the general education effectiveness of the contemporary topics laboratory approach.

Statement of the Problem

This investigation tests the following hypotheses: A contemporary topics (CT) laboratory approach will result in significantly greater achievement than a standard topics (ST) laboratory approach with respect to (1) facts and principles of college physical science, (2) understanding the nature of science and (3) scientific attitude.

The following criteria will be tests for the hypotheses:

(1) Achievement of the subject content of facts and principles of college physical science as measured by an examination developed by the investigator.

(2) Understanding the nature of science as measured by the Welch Science Process Inventory (SPI) (Welch and Pella, 1968).

(3) Scientific Attitude as measured by the Scientific Attitude Inventory (SAI) (Moore and Sutman, 1970).

Statement of the Sub-Problems

Is there significant difference in subject content achievement, in the understanding of the nature of science, or scientific attitude with respect to ---

(1) parental education

(2) parental occupation

(3) college curriculum

(4) year in college

(5) quantity of high school units in science

Definition of Terms

1. Achievement: accomplishment on proficiency of performance in a given skill or body of knowledge (Good, 1973).
2. Attitude, scientific: a set of emotionally toned ideas about science and scientific method, related directly or indirectly to a course of action; in the literature of science education, the term implies such qualities of mind as intellectual curiosity, passion for truth, respect for evidence, an appreciation of the necessity for free communication in science (Good, 1973).
3. General Education Oriented -
   (a) General Education: those phases of learning which should be common experience of all men and women (Good, 1973).
   (b) Oriented: a predisposition toward certain values.
4. Nonscience major - students majoring in fields not associated with biology, chemistry, physics, geology or chemistry.
5. Principles, scientific: a group of generalizations based on observations, all consistent within the limits of observational error, that scientists often accept as equivalent to facts. (Good, 1973).
6. Science major - students majoring in fields associated with biology, chemistry, physics, geology, or chemistry.
7. Subject content: a school subject in which the acquisition of information or knowledge is the chief aim (Good, 1973).
8. Understanding the Nature of Science -
   (a) Understanding: the process of gaining or developing the meaning of various types of material or knowledge (Good, 1973).
   (b) Nature of Science: the scientific enterprise, scientists, and the methods and aims of science (Cooley and Klopfer, 1961).

Note: The various treatment groups will be defined and described in Chapter III.

Limitations of the Study

1. The population for this study was limited to physical science students at the college level at one institution.
2. The sample to be used for experimental purposes consisted of all students taking Elements of Physics and Chemistry at Kutztown State College in Kutztown, Pennsylvania in Spring 1978 semester.
3. The treatment sections were formed by dividing two time equivalent periods into four ability equivalent treatment groups based on student records of S.A.T. total scores.

CHAPTER II

REVIEW OF LITERATURE AND RELATED STUDIES

Purpose of the Review

The review was conducted to survey professional books and journals to determine the status of current research related to the topic; and to become familiar with procedures, activities and findings that might be relevant to this study.

Major Sources Consulted

1. Dissertation Abstracts, University Microfilms, Ann Arbor, Michigan, January, 1960 - latest issue, February, 1978.

2. Education Index, The H.W. Wilson Co., New York, January 1960 - latest issue, February, 1978.

3. Educational Research Information Center, The United States Office of Education, Washington, D.C., January, 1966 - latest issue, February, 1978.

4. Encyclopedia of Educational Research, American Education Research Association, The Macmillan Company, New York, 1969.

5. Gage, Nathaniel L. (Ed.) Handbook of Research on Teaching, Rand McNally, Chicago, 1963.

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Time Limits of the Survey

This study is concerned with the contemporary view of science for nonscience majors. Science for nonscience majors as part of college general education has been discussed frequently through the decades of the twentieth century, and often within the context of the progressive education movement (Heil, 1952). Within the past twenty years courses for the nonscience majors have been discussed more often than courses for majors (CCP, 1964, Cassidy, 1972). Discussions of the value of science for nonscience majors have sometimes focused on the need for providing a scientifically literate society (Pella, et al, 1966).

The 1960's represented a new era of science curriculum development that has modified and influenced our current science programs at all levels. Assuming that the references such as Encyclopedia of Educational Research (1969), Handbook of Research on Teaching (1963),

Rethinking Science Education (1960), Research in Science Education 1938-1947 (1969), adequately cover the contributions prior to 1960, the review concentrated upon the years from 1960 to the present.

Most Helpful Studies or Reports

The literature search focuses on articles, studies and reports that deal with college science for nonscience majors, general education, science literacy, understanding the nature of science, laboratory approaches and scientific attitude.

General Education and Science for Nonscience Majors

The term "general education" is used to describe an educational program designed to educate the "whole man". In Chapter I the term was explained and its relationship to science for non-majors, both the factual information and the kinds of analysis, thinking and procedures can be "extended and translated into problem-solving activities in which students should engage when endeavoring to meet their immediate and future needs" (Heil, 1952).

Within the context of this study the results of studies by Hatcher, Baxter, Simpson and the PSNS project on science for nonscience majors and science for general education were very helpful.

The study by Benjamin Hatcher (1958) investigated the effects of these different instructional patterns, namely, a high degree of student participation; using group discussion; and a low degree of student participation using class recitation. He found no significant differences in the use of the different instructional patterns but he felt the slightly higher scores by the group method, coupled with a subjective feeling of more effectiveness with that method, should provide insights to additional studies.

Kendall Baxter (1968) compared the relative effectiveness of three methods of teaching a general education physical science course. The three methods of teaching used were: (1) a subject matter centered approach; (2) an approach which emphasized the historical development of science and its social and cultural interrelationships; and (3) a historial approach with a laboratory. The determination of the effectiveness was measured by an instructor-constructed test for content and the Test on Understanding Science, Form W for understanding of scientists and the scientific enterprise. Results indicated that the students thought the laboratory approach was most advantageous but the statistical analysis favored only the historial approach without laboratory on only one variable - understanding the nature of science.

A Study which closely resembles this study was done by Faril Simpson (1969). Three laboratory approaches were compared. The instructional approaches were: (1) Traditional, where the student is asked to do a working type experiment; (2) Students are given a choice of doing a prepared experiment, or designing his own; and (3) No experiments were done. Laboratory time was devoted to reading disucssion. Four tests were administered namely a teacher constructed final exam; Test of Science Reasoning and Understanding, Form A; A Test of Critical Thinking, Form G; and Scale to Measure Attitude Toward Any School Subject, Form A. The groups were not found to be significantly different in any respect.

Among the many science curriculum projects of recent years was the Physical Science for Nonscience Students (PSNS) project. Wayne Welch (1972) is very closely associated with the evaluation of the program. George Frangos (1971) used the instrument developed by Welch to study

an adapted PSNS program. Frangos used a Solomon Four Group Design and concluded that the laboratory oriented adapted PSNS model was effective in contributing to the general education objectives of such courses.

This review of the literature indicates that the general education objectives and goals should be tested without a focus on the subject content. Although only one study showed measurable differences in the general education objectives, all the studies reported a need for continued search for methods of teaching general education nonscience major courses and the subsequent evaluation of them.

Science Literacy and Understanding the Nature of Science

Milton Pella and his associates (1966) have been leaders in the investigation of the contemporary view of general education value of science called science literacy. The "referents to science literacy" have provided a conceptual frame of reference for many contemporary investigations (Pella, et al 1966; Agin, 1974).

Leake and Hinerman (1973) relate the investigation of two scientific literacy referents: conceptual knowledge and the processes of science. This study used the Sequential Tests of Educational Progress (STEP) and the Wisconsin Inventory of Science Processes (WISP) to investigate possible correlations of scientific literacy and several other variables such as age, geographic location, class size, etc. John Fowler (1969) when discussing courses for non-majors explains the importance of content and process which are the same as the two referents studied by Leake and Hinerman.

The focus of the present study was on the referent called the nature of science. Doran et al (1974), Jungwirth (1974), and Mackay (1971) have investigated or reported on investigations on measuring

the "Understanding of the Nature of Science." These studies analyze past and current attempts to measure the level of understanding the nature of science. Two instruments have been used extensively in the measurement of the "Understanding of the Nature of Science"; they are the Test on Understanding Science (TOUS) and the Wisconsin Inventory of Science Processes (WISP) (Cooley and Klopfer, 1961; Welch and Pella, 1968). Katherine Jones (1969) contrasted "understandings about the scientific enterprise, scientists and aims and methods of science" between non-majors and professionally oriented students. The non-majors had a course designed to meet general education objectives, while the professionally oriented had the standard science major courses. She found that the non-majors made greater gains in "understandings", while the majors advanced considerably in content. She concluded that emphasis on general education objectives are appropriate, and was confident that more can be done to raise the content achievement of non-majors and the general education goals of the professionals.

A recent study by Gibbons (1976) sought to identify and specify an operational definition of scientific literacy: scientific attitudes, process skills and concepts. This study compared scientific literacy achievement in three ways: (1) the mastery of subject content; (2) the "Understanding of the Nature of Science"; and (3) scientific attitude.

Robert Fredenburg (1965) compared two different orientations of the lecture portion of a college general education physical science course. An interest questionnaire data analysis failed to indicate that either orientation was superior. This study compares two different orientations of the laboratory portion of a similar course.

"Science-in-the-News", an instructional approach which focuses on

those topics of science presented in the media, was used as an instructional vehicle during the 1940's and early 1950's but was discontinued as common practice in the late 1950's. W.C. Van Deventer was a proponent of this instruction during that period and recently has re-introduced this method as a means of achieving understanding of the nature of science (Van Deventer, 1977).

This section of the lierature review defines the terminology and the scope of the topic of science literacy as it relates to general education science courses. The concept that attitudes and understanding of science are related to general education but apart from content is reinforced. From the referents of science literacy this study will focus on the development of two instructional strategies which will take place in the laboratory and measure attitude, understanding the nature of science and subject content.

Scientific Attitude and Attitudes Toward Science

Aiken and Aiken (1969) provide a comprehensive view of the research on attitudes concerning science. They begin by differentiating between the scientific attitude which is a cognitive concept "of adhering to the scientific method" and attitudes toward science which is an affective concept "of like vs. dislike" (p.295). The measurement of science attitude was recently reviewed by Richard Pearl (1974). Pearl represents the history, theory and availability of measurement instruments. He strongly recommends that investigators use an available scale rather than developing another instrument. Among the instruments reviewed included the Scientific Attitude Inventory which was developed by Richard Moore at Temple University (Moore and Sutman, 1970). The Moore instrument is used in this study as one of three criteria instruments. Wilson

(1975) and Dickinson (1975) have used the Moore instrument to measure attitude changes in college level general education science courses.

The Dickinson (1975) study compared a lecture-only and a lecture-laboratory approach in a general education biological science course. The findings indicate that the laboratory was beneficial in reaching general education objectives. The Wilson (1975) study evaluated the use of an anthology of articles on scientific attitude and the understanding of science. The TOUS and SAI were used to measure the effectiveness of the treatment. The results favored the experimental group. The Moore instrument has also been used to measure the scientific attitude of pre-service elementary teachers (Gabel, Rubba, and Franz, 1977) and in-service elementary teachers (Earl and Winkeljohn, 1977).

This section of the literature review reports on the specific topic of scientific attitude. The search shows that scientific attitude has been measured effectively at the college level as goal of general education.

Laboratory and Non-Laboratory Approaches

It is not the intention of this portion of the review to deal with the long term issue on the value of the laboratory. For this study the focus will be on what can be done in the laboratory to foster general education or science literacy objectives.

Robert Bradley (1968) carefully analyzed six important studies on the value(s) of the laboratory in meeting the objectives of general education. The studies included were by Kruglak, Ward, Johnson, Knox and White. Using the conclusions from each study, he showed that either the lecture/demonstration or laboratory method can be supported equally well. He concludes that decisions for inclusion or exclusion of a

laboratory should be made on another basis (i.e. cost). The studies did show that the laboratory method taught manipulative skills; but such skills are not included in the objectives of general education.

In addition to the Simpson (1969) study, previously described, it would be of value to note four additional studies which deal with the use of the laboratory as a vehicle to achieve general education on scientific literacy objectives.

Costa (1973) made a comparison of three approaches to laboratory experiences: (1) direct laboratory (2) vicarious laboratory and (3) descriptive narrative. He used the Science Attitude Inventory by Moore, the Test on Understanding Science and an achievement test as criterion instruments. There were no significant differences on any of the criteria.

Gunsch (1972) compared a laboratory approach (PSNS) to a non-laboratory approach. Both content and attitude variables were measured. The study concluded that the laboratory is of value in courses intended for general education.

Rogers (1972) compared a laboratory-centered approach to a group discussion approach. Achievement, critical thinking and attitudes toward science were measured as criteria. This study raised doubts as to the best method and suggested study of other instructional methods.

Zingaro and Colette (1967-1968) made a statistical comparison of inductive and traditional laboratories in college physical science. The criterion instruments included the Test on Understanding Science and the Watson-Glazer Critical Thinking Appraisal. The authors found that the inductive method proved better in achievement of critical thinking. It was suggested that if the laboratory activities can be

planned to meet general education objectives they will succeed in reaching these objectives.

This section of the literature review focuses on the laboratory phase of the course as being the location of the treatment differences. The reported results were mixed but this investigation chose the laboratory phase for this study based on the evidence that the attitudes and understanding can be effected in the laboratory and this phase of the course is more personal than the large group in the lecture setting.

Literature Review Summary

Within this chapter the investigator has attempted to provide an overview of the literature survey on the topics related to this study. These topics include general education in science for nonscience majors; science literacy, which includes an understanding of the nature of science, scientific attitude and attitude toward science; and the role of the science laboratory in courses for non-majors.

The review of selected science education research was most beneficial in the identification and clarification of the following:

(1) The present study related specifically to a course which is offered exclusively to meet the general education objectives of the college curriculum for nonscience majors. The literature review indicated a strong possibility that the value of general education can be measured.

(2) The concept of science literacy has provided some operational definitions which will facilitate the measurements. Scientific attitude, the understanding of the nature of science and the subject content are clearly differentiated.

(3) The choice of laboratory phase of the course as the experimental treatment differential is appropriate for the laboratory provides a maximum personal instructional situation.

The design to follow will draw upon the concepts of general education and scientific literacy and the techniques and instruments used in measuring the understanding of the nature of science, scientific attitude and subject content of scientific principles.

CHAPTER III

DESIGN OF THE STUDY

Development of the Experiment

This study was designed to investigate the differences in two methods of instruction of nonscience majors in terms of three criteria variables: (1) achievement of physical scientific facts and principles, (2) understanding the nature of science and (3) scientific attitude. The student sample was divided into two treatment groups. The experimental treatment was called contemporary topics approach (CT). The CT approach uses contemporary articles, readings, discussion and a laboratory exercise. The control treatment was called standard topics approach (ST). The ST approach used standard textbook readings, discussion and a laboratory exercise.

The experimental treatment was developed during the Fall 1976, Spring 1977 and Fall 1977 semesters. Three instructors were involved in developing the experimental treatment procedures. During the initial semester it was thought that experiments could be developed around the topics of interest to the students. The instructors felt it took too many weeks to identify the topics and construct the laboratory exercises and they suggested structuring around prescribed contemporary topics. During the following semesters the topics identified in the initial semester were used. The instructor was able to pre-plan the laboratory experiences and structure the reading assignments. In discussion with the instructors involved during the pilot period it was determined that they preferred the structured method of pre-identified topics and exercises. It was decided to develop further the topics and reading selections.

The treatment period was eight weeks for both groups. During that time each group attended two one-hour lecture periods per week. The laboratory periods varied as per treatment while all students in the sample attended the same lecture.

Description of the Treatments

The experimental treatment (CT) studied seven topics: (1) Scientific Method(s) (2) Satellites and Missiles (3) Solar Energy (4) Mechanical/Electrical Energy (5) Nuclear Energy (6) Lasers and (7) Sound. The 110-minute period was divided into two half-periods. The first half-period was used to discuss the student written reports on the topic and to discuss and identify the physics topics included. The second half-period involved the students in a prepared exercise/experiment dealing with a physics topic covered in the discussion.

The control treatment (ST) consisted of seven experiments that have been used for the laboratory part of this course for several years. In order to keep the content of the two laboratory approaches as similar as possible the following experiments were used: (1) Analysis of An Experiment (2) Velocity and Acceleration (3) Specific Heat (4) Electricity and Magnetism (5) Radioactivity (6) Wave Characteristics: Reflection and Refraction and (7) Wave Intensity: Photometry. The entire 110-minute laboratory period was used to complete the prepared experimental procedures.

Both treatment groups were given reading assignments of equivalent difficulty to prepare them for the activities of their respective laboratory periods. Both groups were required to submit a written summary of the reading assignments.

Description of the Sample

The study involved all students enrolled during the Spring 1978 semester in the course Elements of Physics and Chemistry (Phy 10) at Kutztown State College (Penna.).

Initial registration placed ninety-eight (98) students in the course. Following the drop and add period the lecture section reduced to eighty-six (86) with fifty (50) in the Tuesday laboratory period and thirty-six (36) students in the Thursday laboratory period. The lecture met at 12:00 noon on Tuesday and Thursday. The laboratory periods were scheduled from 1:00 - 3:00 p.m. on Tuesday and Thursday. A treatment model was derived from these time equivalent periods as shown in figure one (1). Each laboratory group was divided into two treatment groups.

Phy 10 Lecture
(Investigator)

Tuesday Lab Section 1		Thursday Lab Section 2	
Treatment TuCT Group Lab Inst. 1 (n = 26)	Treatment TuST Group Lab Inst 2 (n = 24)	Treatment ThCT Group Lab Inst. 3 (n = 19)	Treatment ThST Group Lab Inst. 1 (n = 17)

Figure 1

TREATMENT MODEL

Using the S.A.T. total scores from the student records the computer alternated placement in each of the treatment groups within the laboratory day scheduled by the student.

Figure one (1) is a model showing that the lecture group was divided into Tuesday and Thursday groups and then divided again into the experimental contemporary topics group and the control standard topics group. Analysis of data will test each of the four laboratory groups and the two composite treatment groups.

Treatment Monitoring

The investigator prepared an instructor's manual for both the experimental and control treatments. The manual provided the instructor with the weekly reading assignments, photocopies of the readings and the exercises. Some notes for potential discussion were included. The investigator visited the various groups during the first few weeks to be sure the students and instructor were following the treatment format. Midway through the treatment period the investigator decided to apply a written tool to assist in the monitoring of the treatment. A student perception questionnaire was prepared and applied during the last week of the treatment (Appendix D).

Criteria Instruments

Students were pretested and posttested for three dependent variables: achievement of subject content of scientific facts and principles, understanding the nature of science, and scientific attitude.

1. To test for student achievement of physical science facts and principles an objective test was constructed by the investigator. The test contains seventy (70) multiple choice questions with items selected from previously applied departmental course tests and covering all topics to be covered during the eight-week treatment period. The pretest and posttest were very similar with the same number of questions in the same topic area but with differently worded ques-

tions.

Test items were drawn from the large bank of test questions used each semester for this course. No special items were added due to the differential laboratory treatments. Test analysis was not applied since the nature of test and test items conformed with departmental practice of many semesters.

2. To test the understanding of the nature of science the Science Process Inventory (SPI), form D, developed by Wayne Welch was used with his permission. The instrument was reported initially as form C with 150 items (Welch and Pella, 1978). Form D is a modification with 135 items about the activities, assumptions, products, and ethics of science. Students respond by agreeing or disagreeing with each item. Validity and reliability information was obtained from the author directly (Welch, 1978). The Kuder-Richardson formula 20 estimate of reliability of 0.86 on a sample of 171 students.

The instrument has been used by Richard Cannon (1975) who was comparing two laboratory methods of general education college physical science and Joel Dawson (1975) in comparing two instructional strategies of a college biology laboratory course. Neither study provided additional reliability data other than that provided by the test author.

3. To test for scientific attitude the Scientific Attitude Inventory (SAI) constructed and validated by Richard Moore at Temple University was used with his permission. A reliability coefficient of 0.934 was calculated by Moore using the test-retest method. The Moore instrument has been used widely to measure scientific attitude

at the college level including studies by Roosevelt Wilson (1975), Joseph Costa (1973), Leonart Gunsch (1972) and Donald Dickinson (1975). Of these studies only Dickinson reported reliability data supplemental to Moore's original data. Dickinson in comparing attitude change in a lecture-only versus a lecture-laboratory approach reported a reliability coefficient of 0.73 using the Kuder Richardson formula 20.

Statistical Analysis

For all three dependent variables, achievement of physical science facts and principles, understanding the nature of science, and scientific attitude, statistic analysis was applied as follows: (1) to assure intergroup homogeneity on the pretest scores an analysis of variance was applied; (2) to determine change within the group a dependent t-test was applied; and (3) to measure change between groups an analysis of covariance was applied. Figure two (2) shows the four-group design used in the statistical analysis of each treatment group.

	Treatment CT	Treatment ST
Section Tu	$\bar{X}$ Tu CT	$\bar{X}$ TuST
Section Th	$\bar{X}$ Th CT	$\bar{X}$ ThST

Figure 2

FOUR-GROUP ANALYSIS DESIGN

For the purpose of analysis of treatment effect the two treatment groups were combined to form a composite treatment group.

Figure three (3) shows the two group design used in the statistical analysis of the composite treatment groups which constitute the experimental and control treatments.

	Treatment CT	Treatment ST
Composite Tu & Th	$\bar{X}$ Comp. CT	$\bar{X}$ Comp. ST

Figure 3

TWO-GROUP ANALYSIS DESIGN

For the treatment monitoring perception questionnaire the chi square (X^2) statistic was applied.

In the tables of chapter four (IV), starting on page forty (40), notations will be used in place of full descriptors of the treatment groups. These notations are used in figures 2 and 3 and are explained in figure four (4).

Tuesday Standard Topics	= Tu ST	(n=24)
Tuesday Contemporary Topics	= Tu CT	(n=26)
Thursday Standard Topics	= Th ST	(n=17)
Thursday Contemporary Topics	= Th CT	(n=19)
Composite Standard Topics	= Comp. ST	(n=41)
Composite Contemporary Topics	= Comp. CT	(n=45)

Figure 4

TABLE NOTATIONS

CHAPTER IV

ANALYSIS OF DATA

The findings of this chapter are based on student achievement of facts and principles of physical science, change in the understanding of the nature of science and change in scientific attitude under two different laboratory topic approaches. These approaches were (1) a standard topics approach with readings from textbooks and (2) a contemporary topics approach with readings from articles.

Principal Hypotheses

There are three principal hypotheses of this study. For statistical analysis they will be stated in the null form in the section on posttreatment data and analysis.

(1) There will be no statistically significant difference in the mean scores of the standard topics group and the contemporary topics group measured on an instructor-prepared subject content test.

(2) There will be a statistically significant difference in the mean scores of the standard topics group and the contemporary topics group as measured on the Science Process Inventory (SPI) for the understanding of the nature of science.

(3) There will be a statistically significant difference in the mean scores of the standard topics group and the contemporary topics group as measured on the Scientific Attitude Inventory (SAI)/

Statistical Treatment of Data

This section focuses on the statistical treatment of the data on the three principal hypotheses. The first sub-section is concerned with the pretreatment data and the analysis is used to demonstrate intergroup homogeneity. The second sub-section contains the post-

treatment data and analysis which is used to measure the effect of the treatments. The third sub-section reports the data and analysis for the sub-problems.

Pretreatment Data and Analysis

Assignment to the treatment within the assigned laboratory times (Tuesday or Thursday 1:00 p.m.) was done by the computer record of student S.A.T. total scores. This was done in such a manner that all treatment groups would be of equal ability in reference to this criterion. The investigator was concerned that the students who might add or drop the course might influence the intergroup homogeneity. Also he was concerned that the group be equivalent on the criterion variables as well as the S.A.T. total scores. These concerns justified the use of statistical tests on the pretest scores on the subject content test, the Science Process Inventory and the Scientific Attitude Inventory.

Table 1 presents the mean scores and standard deviation from the S.A.T. totals on record for the four treatment groups and the two composite groups.

Table 1

PRETREATMENT S.A.T. TOTAL SCORES TEST FOR HOMOGENEITY

Group Data	Tuesday Standard Topics	Tuesday Contemp. Topics	Thursday Standard Topics	Thursday Contemp. Topics	Composite Standard Topics	Composite Contemp. Topics
Mean	903.3	882.7	929.3	828.9	914.0	860.0
St. Dev.	174.8	191.7	173.2	330.4	174.6	260.8

Application of an independent t-test showed no significant differences between any of the individual treatment groups or the composite

treatment groups at 0.01 level.

Table 2 presents the mean scores and standard deviation for the pretest on subject content for the four treatment groups.

Table 2

PRETEST MEAN SCORES AND STANDARD DEVIATION ON THE SUBJECT CONTENT TEST FOR THE FOUR TREATMENT GROUPS AND THE TWO COMPOSITE TREATMENT GROUPS.

Group Data	Tuesday Standard Topics	Tuesday Contemp. Topics	Thursday Standard Topics	Thursday Contemp. Topics	Composite Standard Topics	Composite Contemp. Topics
Mean	28.1	27.8	28.5	25.7	28.3	26.9
S.D.	4.6	6.8	7.1	6.9	5.8	6.9

Table 3 presents the analysis of variance on the pretest scores on the subject content for the four treatment groups.

Table 3

ANALYSIS OF VARIANCE ON PRETEST SCORES ON THE SUBJECT CONTENT FOR THE FOUR TREATMENT GROUPS

Source of Variance	Sum of Squares	df	Mean of Squares	F-Ratio
Between Groups	90.99	3	30.33	0.713
Within Groups	3486.22	82	42.51	
Total	3577.21	85		

The F-Ratio is not statistically significant at the 0.05 level. Therefore, the four groups were statistically equivalent on the subject content before the treatment.

Table 4 presents the analysis of variance on the pretest scores on the subject content for the two composite treatment groups.

Table 4

ANALYSIS OF VARIANCE OF PRETEST SCORES ON THE SUBJECT CONTENT FOR THE TWO COMPOSITE TREATMENT GROUPS

Source of Variance	Sum of Squares	df	Mean of Squares	F-Ratio
Between Groups	39.51	1	39.51	0.938
Within Groups	3537.69	84	42.11	
Total	3577.20	85		

The F-Ratio is not statistically significant at the 0.05 level. Therefore, the two composite groups were statistically equivalent on the subject content before the treatment.

Table 5 presents the mean scores and standard deviation for the pretest on the understanding of the nature of science (SPI) for the four treatment groups and the two composite treatment groups.

Table 5

PRETEST MEAN SCORES AND STANDARD DEVIATION ON THE SCIENCE PROCESS INVENTORY FOR THE FOUR TREATMENT GROUPS AND THE TWO COMPOSITE TREATMENT GROUPS

Group Data	Tuesday Standard Topics	Tuesday Contemp. Topics	Thursday Standard Topics	Thursday Contemp. Topics	Composite Standard Topics	Composite Contemp. Topics
Mean	108.8	106.3	105.2	104.3	107.3	105.9
S. D.	6.7	10.0	8.5	6.4	7.7	8.7

Table 6 presents the analysis of variance on the pretest scores on the understanding of the nature of science (SPI) for the four treatment groups.

Table 6

ANALYSIS OF VARIANCE OF PRETEST SCORES ON THE SCIENCE PROCESS INVENTORY FOR THE FOUR TREATMENT GROUPS

Source of Variance	Sum of Squares	df	Mean of Squares	F-Ratio
Between Groups	251.93	3	83.97	1.201
Within Groups	5733.68	82	69.92	
Total	5985.61	85		

The F-Ratio is not statistically significant at the 0.05 level. Therefore, the four groups were statistically equivalent on the understanding of the nature of science before the treatment.

Table 7 presents the analysis of variance on the pretest scores on the understanding of the nature of science (SPI) for the two composite treatment groups.

Table 7

ANALYSIS OF VARIANCE OF PRETEST SCORES ON THE SCIENCE PROCESS INVENTORY FOR THE TWO COMPOSITE TREATMENT GROUPS

Source of Variance	Sum of Squares	df	Mean of Squares	F-Ratio
Between Groups	77.18	1	77.19	1.097
Within Groups	5908.43	84	70.34	
Total	5985.62	85		

The F-Ratio is not statistically significant at the 0.05 level. Therefore, the two composite groups were statistically equivalent on the understanding of the nature of science before the treatment.

Table 8 presents the mean scores and standard deviation on the pretest on scientific attitude (SAI) for the four treatment groups and the two composite treatment groups.

Table 8

PRETEST MEANS AND STANDARD DEVIATION ON THE SCIENTIFIC ATTITUDE INVENTORY FOR THE FOUR TREATMENT GROUPS AND THE TWO COMPOSITE TREATMENT GROUPS

Group / Data	Tuesday Standard Topics	Tuesday Contemp. Topics	Thursday Standard Topics	Thursday Contemp. Topics	Composite Standard Topics	Composite Contemp. Topics
Mean	114.7	118.9	116.9	117.4	115.6	118.3
S.D.	13.2	9.8	13.2	8.3	13.3	9.2

Table 9 presents the analysis of variance on the pretest scores on the scientific attitude (SAI) for the four treatment groups.

Table 9

ANALYSIS OF VARIANCE OF PRETEST SCORES ON THE SCIENTIFIC ATTITUDE INVENTORY FOR THE FOUR TREATMENT GROUPS

Sources of	Sum of Squares	df	Mean of Squares	F-Ratio
Between Groups	225.00	3	75.00	0.560
Within Groups	10979.00	82	133.89	
Total	11204.00	85		

The F-Ratio is not statistically significant at the 0.05 level. Therefore, the four treatment groups were statistically equivalent on scientific attitude before the treatment.

Table 10 presents the analysis of variance on the pretest scores on the scientific attitude (SAI) for the two composite treatment groups.

Table 10

ANALYSIS OF VARIANCE OF PRETEST SCORES ON THE SCIENTIFIC ATTITUDE INVENTORY FOR THE TWO COMPOSITE TREATMENT GROUPS

Sources of Variance	Sum of Squares	df	Mean of Squares	F-Ratio
Between Groups	156.00	1	156.00	1.186
Within Groups	11048.00	84	131.52	
Total	11204.00	85		

The F-Ratio is not statistically significant at the 0.05 level. Therefore, the two composite groups were statistically equivalent on scientific attitude before the treatment.

Pretreatment data summation. In addition to being equivalent on ability based on S.A.T. total scores which were used to assign students to the treatment groups, it has been shown that all treatment groups were equivalent on all treatment dependent variables.

Posttreatment Data and Analysis

The following data and analysis is related to the principal hypotheses. Each hypothesis is stated in the null form.

Hypothesis 1. There will be no statistically significant differences in the mean scores obtained by students in the standard topics groups and the contemporary topics groups as measured on an instructor-prepared subject content test.

Table 11 presents the mean scores and standard deviation for the four treatment groups and the two composite groups on the pretest and posttest on the subject content test.

Table 11

PRETEST AND POSTTEST MEAN SCORES AND STANDARD DEVIATION ON THE SUBJECT CONTENT TEST FOR THE FOUR TREATMENT GROUPS AND THE TWO COMPOSITE TREATMENT GROUPS

Group / Data	Tuesday Standard Topics	Tuesday Contemp. Topics	Thursday Standard Topics	Thursday Contemp. Topics	Composite Standard Topics	Composite Contemp. Topics
Pretest Mean	28.1	27.8	28.5	25.7	28.4	26.9
S.D.	4.6	6.8	7.1	6.9	5.8	6.0
Posttest Mean	49.5	49.9	49.4	48.1	49.5	49.1
S.D.	9.6	9.4	9.1	9.8	9.4	9.6

Application of dependent t-tests to each group showed a statistically significant change in the achievement of facts and principles of physical science within all groups at the 0.01 level.

Table 12 presents the pretest and posttest and the adjusted means on the subject content test for the four treatment groups and the two composite treatment groups.

Table 12

PRETEST, POSTTEST, AND ADJUSTED MEANS ON THE INVESTIGATOR-CONSTRUCTED SUBJECT CONTENT TEST FOR THE FOUR TREATMENT GROUPS AND THE TWO COMPOSITE TREATMENT GROUPS

*	Pretest Mean (X)	Posttest Mean (Y)	Adjusted Mean
Tu ST	28.1	49.5	49.0
Tu CT	27.8	49.9	49.7
Th ST	28.5	49.4	48.5
Th CT	25.7	48.1	49.8
Comp ST	28.3	49.5	48.8
Comp CT	26.9	49.1	49.7

Table 13 presents the analysis of covariance on the test data for hypothesis one (1) for the four treatment groups.

Table 13

ANALYSIS OF COVARIANCE ON THE SUBJECT CONTENT FOR THE FOUR TREATMENT GROUPS

Sources of Variance	Sum of Squares	df	Mean of Squares	F-Ratio
Between Groups	20.78	3	6.93	0.118
Within Groups	4771.86	81	58.91	
Total	4792.64	84		

* Table notations are explained on page 31

The F-Ratio is not statistically significant at the 0.01 level and hypothesis one (1) is not rejected for the four treatment groups.

Table 14 presents the analysis of a covariance on the test data for hypothesis one (1) for the two composite treatment groups.

Table 14

ANALYSIS OF COVARIANCE ON THE SUBJECT CONTENT FOR THE TWO COMPOSITE TREATMENT GROUPS

Sources of Variance	Sum of Squares	df	Mean of Squares	F-Ratio
Between Groups	18.18	1	18.18	0.316
Within Groups	4774.46	83	57.52	
Total	4792.64	84		

The F-Ratio is not statistically significant at the 0.01 level and hypothesis one (1) is not rejected for the two composite treatment groups.

Hypothesis one (1) is not rejected based on the analysis of data for the four treatment groups and the two composite treatment groups.

Hypothesis 2. There will be no statistically significant differences in the mean scores obtained by students in the standard topics groups and the contemporary topics groups as measured on the Science Process Inventory (SPI) for the understanding of the nature of science.

Table 15 presents the mean scores and standard deviation on the pretest and posttest on understanding the nature of science for the four treatment and the two composite treatment groups.

Table 15

PRETEST AND POSTTEST MEAN SCORES AND STANDARD DEVIATION ON THE SCIENTIFIC PROCESS INVENTORY (SPI) FOR THE FOUR TREATMENT GROUPS AND THE TWO COMPOSITE TREATMENT GROUPS

Group / Data	Tuesday Standard Topics	Tuesday Contemp. Topics	Thursday Standard Topics	Thursday Contemp. Topics	Composite Standard Topics	Composite Contemp. Topics
Pretest Mean	108.8	106.3	105.2	104.3	107.3	105.4
S.D.	6.7	10.0	8.5	6.4	7.7	8.7
Posttest Mean	107.9	106.3	105.1	99.8	106.7	103.6
S.D.	6.7	12.0	12.1	11.7	9.4	12.4

Application of dependent t-tests to each group showed no statistically significant change of the understanding of the nature of science within any group at the 0.01 level.

Table 16 presents pretest, posttest, and adjusted mean on the Scientific Process Inventory (SPI) for the four treatment groups and the two composite treatment groups.

Table 16

PRETEST, POSTTEST AND ADJUSTED MEANS ON THE SCIENCE PROCESS INVENTORY FOR THE FOUR TREATMENT GROUPS AND THE TWO COMPOSITE TREATMENT GROUPS

*	Pretest Mean (X)	Posttest Mean (Y)	Adjusted Mean
Tu ST	108.7	107.9	105.9
Tu CT	106.3	106.3	106.3
Th ST	107.3	106.7	105.9
Th CT	104.3	99.8	101.4
Comp. ST	107.3	106.7	105.9
Comp. CT	105.4	103.6	104.3

* Table notations are explained on page 31.

The analysis of covariance on the data on understanding the nature of science for the four treatment groups resulted in an F-Ratio of 1.345 and for the two composite treatment groups an F-Ratio of 1.097. These F-Ratios are not statistically significant at the 0.01 level and hypothesis two (2) is not rejected.

Hypothesis 3. There will be no statistically significant difference in the mean scores obtained by students in the standard topics groups and the contemporary topics groups as measured on a Scientific Attitude Inventory (SAI).

Table 17 presents the mean scores and standard deviation for the pretest and posttest on scientific attitude for the four treatment and two composite groups.

Table 17

PRETEST AND POSTTEST MEAN SCORES AND STANDARD DEVIATION ON THE SCIENTIFIC ATTITUDE INVENTORY FOR THE FOUR TREATMENT GROUPS AND THE TWO COMPOSITE TREATMENT GROUPS

Group / Data	Tuesday Standard Topics	Tuesday Contemp. Topics	Thursday Standard Topics	Thursday Contemp. Topics	Composite Standard Topics	Composite Contemp. Topics
Pretest Mean	114.7	118.9	116.8	117.4	115.6	118.3
S.D.	13.2	9.8	13.2	8.3	13.3	9.2
Posttest Mean	115.0	116.7	120.5	115.7	117.3	116.3
S.D.	15.3	9.2	17.0	12.2	14.9	10.6

Application of dependent t-tests to each group showed no statistically significant change of the scientific attitude within any group at the 0.01 level.

Table 18 presents pretest, posttest and adjusted means on the Science Attitude Inventory (SAI) for the four treatment groups and the two composite groups.

Table 18

PRETEST, POSTTEST, AND ADJUSTED MEANS ON THE SCIENCE ATTITUDE INVENTORY FOR THE FOUR TREATMENT GROUPS AND THE TWO COMPOSITE TREATMENT GROUPS

*	Pretest Mean (X)	Posttest Mean (Y)	Adjusted Mean
Tu ST	114.7	115.0	116.9
Tu CT	118.9	116.7	115.1
Th ST	116.8	120.5	120.6
Th CT	117.4	115.7	115.4
Comp. ST	115.6	117.3	118.45
Comp. CT	118.3	116.3	115.21

The analysis of covariance on the data on scientific attitude for the four treatment groups resulted in an F-Ratio of 1.556 and for the two composite treatment groups an F-Ratio of 2.858. These F-Ratios are not statistically significant at the 0.01 level and hypothesis three (3) is not rejected.

Sub-Problem Data and Analysis

The sub-problems of this study were concerned with the effect of student background on the criteria variables. The biographical background data used was the parental education and occupation and the student's college curriculum, year in college and number of high school science units.

* Table notations are explained on page 31.

Sub-problem 1. Is there a statistical difference in subject content achievement, in understanding the nature of science or scientific attitude with respect to parental education?

Student biographical data was collected to determine the appropriate highest educational level of either parent. A three-group classification was determined: (1) high school level (H.S.); (2) two-year college, technical or professional/associate level (C2); and (3) four-year college level and postgraduate studies (C4).

Table 19 presents the pretest and posttest mean scores for the three educational groups based on all criterion variables.

Table 19

PRETEST AND POSTTEST MEAN SCORES ON SUBJECT CONTENT, UNDERSTANDING THE NATURE OF SCIENCE, AND SCIENTIFIC ATTITUDE FOR THE THREE GROUPS BY PARENTAL EDUCATION

Group	(n)	Subject Content		Understanding the Nature of Science		Scientific Attitude	
		Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean
HS	53	27.6	49.3	105.1	104.1	115.5	115.1
C2	10	29.2	52.2	106.0	105.4	117.2	120.3
C4	23	26.5	47.8	109.0	107.0	120.0	118.4

Analysis of variance on the pretest scores on all variables showed no statistically significant difference existed before the treatment. Analysis of covariance using the posttest scores on all variables showed no statistically significant difference following treatment. For these treatments it is accepted that parental educational level was not an influence in achievement of subject content, understanding the nature of

science or scientific attitude.

Sub-problem 2. Is there a statistical difference in subject content achievement, in understanding the nature of science or scientific attitude with respect to parental occupation?

Student biographical data was collected to determine the appropriate highest occupational level of either parent. A three-group classification was determined: (1) blue collar (BC); (2) white collar (WC); and (3) professional (Prof.).

Table 20 presents the pretest and posttest mean scores for the three occupational groups on all criterion variables.

Table 20

PRETEST AND POSTTEST MEAN SCORES ON SUBJECT CONTENT, UNDERSTANDING THE NATURE OF SCIENCE, AND SCIENTIFIC ATTITUDE FOR THE THREE GROUPS BY PARENTAL OCCUPATION

Group	(n)	Subject Content		Understanding the Nature of Science		Scientific Attitude	
		Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean
BC	41	27.7	50.7	105.3	103.6	115.9	114.6
WC	27	27.4	47.2	105.6	106.0	115.5	117.9
Prof.	18	27.3	49.2	109.6	106.9	121.3	119.1

Analysis of variance on the pretest scores on all variables showed no statistically significant differences existed before the treatment. Analysis of covariance using the posttest scores on all variables showed no statistically significant difference following treatment. For these treatments, it is accepted that parental occupational level was not an influence in achievement of subject content, understanding the nature of science, or scientific attitude.

Sub-problem 3. Is there a statistical difference in subject content achievement, in understanding the nature of science or scientific attitude with respect to the student's college curriculum?

Student biographical data and college records indicated that the sample could be appropriately classified into four groups: (1)Teacher Education (TE); (2) Liberal Arts - B.A. (BA); (3) Liberal Arts - B.S. (BS); and (4) School of Art (Art).

Table 21 presents the pretest and posttest mean scores on the four curriculum groups based on all criterion variables.

Table 21

PRETEST AND POSTTEST MEAN SCORES ON SUBJECT CONTENT, UNDERSTANDING THE NATURE OF SCIENCE AND SCIENTIFIC ATTITUDE FOR THE FOUR GROUPS BY COLLEGE CURRICULUM

Group	(n)	Subject Content		Understanding the Nature of Science		Scientific Attitude	
		Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean
TE	52	25.9	47.3	105.3	103.7	115.1	114.8
BA	21	30.2	51.2	107.3	105.3	119.6	120.5
BS	10	29.4	55.4	109.2	108.7	119.0	115.1
Art	3	29.7	47.7	103.3	113.3	122.0	127.3

Analysis of variance on the pretest scores on all variables showed no statistically significant differences existed before the treatment. Analysis of covariance using the posttest scores on all variables showed no statistically significant difference following treatment. For these treatments, it is accepted that college curriculum was not an influence in achievement of subject content, understanding the nature of science

or scientific attitude.

Sub-problem 4. Is there a statistical difference in subject content achievement, in understanding the nature of science or scientific attitude with respect to student's year in college?

Student biographical data and college records indicated that the sample had students representing each of the four undergraduate years.

Table 22 presents the pretest and posttest mean scores for the four years of undergraduate studies based on all criterion variables.

Table 22

PRETEST AND POSTTEST MEAN SCORES ON SUBJECT CONTENT, UNDERSTANDING THE NATURE OF SCIENCE, AND SCIENTIFIC ATTITUDE FOR THE FOUR GROUPS BY YEAR IN COLLEGE

Group	(n)	Subject Content		Understanding the Nature of Science		Scientific Attitude	
		Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean
1 yr.	28	27.7	49.9	105.7	102.5	118.0	118.9
2 yr.	43	27.2	48.8	105.7	105.9	115.8	115.2
3 yr.	8	28.1	47.9	106.7	106.6	119.0	116.6
4 yr.	7	28.3	50.6	111.7	108.9	116.6	116.0

Analysis of variance on the pretest scores on all variables showed no statistically significant differences existed before the treatment. Analysis of covariance using the posttest scores on all variables showed no statistically significant differences following treatment. For these treatments, it is accepted that year in college was not an influence in achievement of subject content, understanding the nature of science or scientific attitude.

Sub-problem 5. Is there a statistical difference in subject content achievement, in understanding the nature of science or scientific attitude with respect to student's number of high school science units?

Student biographical data and college records indicated that the sample had students ranging from one to four high school science units.

Table 23 presents the pretest and posttest mean scores for the science background based on all criterion variables.

Table 23

PRETEST AND POSTTEST MEAN SCORES ON SUBJECT CONTENT, UNDERTSTANDING THE NATURE OF SCIENCE, AND SCIENTIFIC ATTITUDE FOR THE FOUR GROUPS BY HIGH SCHOOL SCIENCE UNITS

Group	(n)	Subject Content		Understanding the Nature of Science		Scientific Attitude	
		Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean	Pretest Mean	Posttest Mean
1 unit	1	23.0	38.0	99	97	97	98
2 units	18	26.6	46.9	108.7	106.7	118.9	120
3 units	35	26.2	48.1	105.1	104.3	115.1	113.7
4 units	32	29.7	52.2	106.5	105.2	118.5	118.2

Analysis of variance on the pretest scores on all variables showed no statistically significant differences existed before the treatment. Analysis of covariance using the posttest scores on all variables showed no statistically significant differences following treatment. For these treatments, it is accepted that high school science units were not an influence in achievement of subject content, understanding the nature of science or scientific attitude.

Treatment Monitoring Data

A two-part perception questionnaire was administered to determine if the students were in fact experiencing the treatments as designed.

The fourteen questions of Part A focused on the extent of participation in treatment activities. The five questions of Part B were intended to determine the amount of time spent in each essential activity.

The data for each question is reported in a table of response frequencies followed by a chi square analysis. The format of the questionnaire is given in Appendix D.

Question Set A: Response Frequency and Analysis

The questions of Part A allowed for five responses: (A) Always (100%); (B) Frequently (60-90%); (C) Intermittently (40-60%); (D) Occasionally (10-35%); and (E) Never (0%). Responses A, B and C are affirmative. Responses C and D are negative. The acceptable value of chi square at the 0.05 level is 3.841. Questions with a chi square value below 3.841 will mean the groups responded statistically equivalent. Questions with a chi square value above 3.841 will mean the groups responded statistically different. The criteria questions of Part A are A3, A4, A8, and A10.

Question A1. To what extent did the topics of the readings relate to your personal interest?

Table 24

MONITORING QUESTION A1 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	0	3	7	9	5
Tu CT	0	7	8	9	2
Th ST	0	2	5	9	1
Th CT	0	8	4	6	1

Table 25

MONITORING QUESTION A1 - CHI SQUARE 2 x 2

*	+	-
Comp ST	17	24
Comp CT	27	18

It was expected that the contemporary topics groups would be more affirmative that the standard topics groups. The chi square value of 2.98 indicates that the expectation was not supported. The groups were statistically equivalent in their response to this question. The table shows that the contemporary topics groups were more affirmative but not statistically more affirmative.

* Table notations are explained on page 31.

Question A2. To what extent did the experiments relate to your personal interest?

Table 26

MONITORING QUESTION A2 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	0	1	7	10	6
Tu CT	0	4	8	13	1
Th ST	0	1	5	8	3
Th CT	0	4	9	5	1

Table 27

MONITORING QUESTION A2 - CHI SQUARE 2 x 2

*	+	-
Comp ST	14	27
Comp CT	25	20

It was expected that the contemporary topics groups would be slightly more affirmative than the standard topics groups. The chi square value of 4.70 indicates that the expectation was supported.

* Table notations are explained on page 31.

Question A3. To what extent did you use articles in preparation for the lab period?

Table 28

MONITORING QUESTION A3 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	2	2	3	2	15
Tu CT	3	9	4	7	3
Th ST	2	1	1	3	9
Th CT	7	2	4	4	2

Table 29

MONITORING QUESTION A3 - CHI SQUARE 2 x 2

*	+	-
Comp ST	12	29
Comp CT	29	16

It was expected that the contemporary topics groups would be more affirmative than the standard topics groups. The chi square value of 11.32 indicates that the expectation was supported. This is a criterion question and a check of the response frequency indicates the Thursday contemporary topics group had a much higher degree of conformity with the planned treatment.

* Table notations are explained on page 31.

Question A4. To what extent did you use reference texts in preparation for the lab period?

Table 30

MONITORING QUESTION A4 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	17	3	2	0	2
Tu CT	0	2	1	4	19
Th ST	10	3	0	3	1
Th CT	1	1	0	2	15

Table 31

MONITORING QUESTION A4 - CHI SQUARE 2 x 2

*	+	-
Comp ST	35	6
Comp CT	5	40

It was expected that the standard topics groups would be more affirmative than the contemporary topics groups. The chi square value of 47.96 indicates that the expectation was supported. This is a criterion question and indicates clearly that the standard topics approach was being followed as planned.

* Table notations are explained on page 31.

Question A5. To what extent did you use your text in preparation for the lab period?

Table 32

MONITORING QUESTION A5 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	3	2	4	2	13
Tu CT	1	2	0	4	19
Th ST	1	3	6	2	5
Th CT	1	2	0	4	12

Table 33

MONITORING QUESTION A5 - CHI SQUARE 2 x 2

*	+	-
Comp ST	19	22
Comp CT	6	39

It was expected that the standard topics group would be more affirmative on this question since part of the assignment was to read their text but the assignment did not require a written report. A check of response frequency indicates that the standard topics groups were more affirmative than the contemporary topics but not overall affirmative. A chi square value of 11.01 indicates that the expectation was supported.

* Table notations are explained on page 31.

Question A6. To what extent did your text relate to the topic of the lab experiment?

Table 34

MONITORING QUESTION A6 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	3	4	6	3	8
Tu CT	2	4	11	6	3
Th ST	4	4	6	2	1
Th CT	2	2	4	4	7

Table 35

MONITORING QUESTION A6 - CHI SQUARE 2 x 2

*	+	-
Comp ST	27	14
Comp CT	25	20

It was expected that there would be no difference in the responses to this question. The chi square value of 0.08 indicates that the expectation was supported.

* Table notations are explained on page 31.

Question A7. To what extent did your text relate to the topics of the lecture?

Table 36

MONITORING QUESTION A7 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	7	13	3	0	1
Tu CT	10	10	4	0	2
Th ST	6	6	3	0	2
Th CT	9	6	2	0	2

Table 37

MONITORING QUESTION A7 - CHI SQUARE 2 x 2

*	+	-
Comp ST	38	3
Comp CT	41	4

It was expected that both treatment groups would be affirmative on this question since they shared a common lecture period which made text book assignments. The chi square value of 0.03 indicates that the expectation was supported.

* Table notations are explained on page 31.

Question A8. To what extent did the lab instructor presentation and/or discussion relate to the readings?

Table 38

MONITORING QUESTION A8 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	2	5	5	6	5
Tu CT	14	6	4	2	0
Th ST	1	5	5	4	2
Th CT	6	8	4	1	0

Table 39

MONITORING QUESTION A8 - CHI SQUARE 2 x 2

*	+	-
Comp ST	24	17
Comp CT	42	3

It was expected that the contemporary topics group would be more affirmative on this criteria question. A check of the response frequencies shows the Tuesday contemporary topics group was very affirmative and this would indicate a higher degree of conformity with the planned treatment. The chi square value of 12.74 indicates support for this general expectation.

* Table notations are explained on page 31.

Question A9. To what extent did the lab instructor presentation and/or discussion relate to the experiment?

Table 40

MONITORING QUESTION A9 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	13	9	2	0	0
Tu CT	10	5	10	0	1
Th ST	9	2	4	1	1
Th CT	2	5	7	5	0

Table 41

MONITORING QUESTION A9 - CHI SQUARE 2 x 2

*	+	-
Comp ST	39	2
Comp CT	39	6

It was expected that both treatment groups would be affirmative on this question since introduction to the lab exercise has always been an instructor's responsibility. The chi square value of 2.86 indicates that the expectation was supported.

* Table notations are explained on page 31.

Question A10. To what extent did the lab instructor adequately cover the readings?

Table 42

MONITORING QUESTION A10 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	1	0	3	8	12
Tu CT	9	11	2	3	1
Th ST	9	9	3	7	7
Th CT	8	6	4	1	0

Table 43

MONITORING QUESTION A10 - CHI SQUARE 2 x 2

*	+	-
Comp ST	7	34
Comp CT	40	5

It was expected that the contemporary topics group would be more affirmative on this criteria question. The chi square value of 42.32 indicates that the expectation was supported.

* Table notations are explained on page 31.

Question A11. To what extent did the lab instructor adequately cover the experiments?

Table 44

MONITORING QUESTION A11 - RESPONSE FREQUENCY BY TREATMENT GROUPS

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	8	9	5	0	2
Tu CT	2	10	8	4	2
Th ST	2	8	2	4	1
Th CT	3	4	4	8	0

Table 45

MONITORING QUESTION A11 - CHI SQUARE 2 x 2

*	+	-
Comp ST	34	7
Comp CT	31	14

It was expected that there would be no difference in the responses to this question. The chi square value of 2.48 indicates that the expectation was supported. It is noteworthy that the instructor effect present in all instructional evaluations is very evident in the high ratings given the Tuesday standard topics section.

* Table notations are explained on page 31.

Question A12. To what extent did the lab instructor adequately collect the reading reports?

Table 46

MONITORING QUESTION A12 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	23	0	0	0	1
Tu CT	21	5	0	0	0
Th ST	15	2	0	0	0
Th CT	15	4	0	0	0

Table 47

MONITORING QUESTION A12 - CHI SQUARE 2 x 2

*	+	-
Comp ST	40	1
Comp CT	45	0

It was expected that there would be no difference in the responses to this question. The chi square value of 1.04 indicates that the expectation was supported.

* Table notations are explained on page 31.

Question A13. To what extent did the library readings relate to the experiment?

Table 48

MONITORING QUESTION A13 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (Always)	B (60-90%)	C (40-60%)	D (10-35%)	E (Never)
Tu ST	5	8	5	4	2
Tu CT	3	8	5	7	3
Th ST	4	5	5	3	0
Th CT	0	4	9	2	2

Table 49

MONITORING QUESTION A13 - CHI SQUARE 2 x 2

*	+	-
Comp ST	32	9
Comp CT	29	16

It was expected that both treatment groups would be affirmative on this question. The chi square value of 2.03 indicates that the expectation was not supported. However, it was expected that a greater number of students would make a connection between the topic of the reading and the laboratory exercise in all treatment groups.

* Table notations are explained on page 31.

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standard topics reading on this same topic would have been a chapter on electricity and magnetism. The chi square value of 10.41 indicates the expectation was not supported.

Question-Set B: Response Frequency and Analysis

The questions of Part B allowed for five responses: (A) none; (B) 10-30 minutes; (C) 30-50 minutes; (D) 50-70 minutes; and (E) 70-120 minutes. The appropriate treatment response differs for each question. The acceptable value of chi square at the 0.05 level is 3.841. The criteria questions of Part B are B3 and B5.

Question B1. How much time was spent per week in preparation for the lab by reading in the library and writing reports?

Table 52

MONITORING QUESTION B1 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (none)	B (10-30 min)	C (30-50 min)	D (50-70 min)	E (70-120 min)
Tu ST	3	7	6	6	2
Tu CT	2	2	8	8	6
Th ST	0	5	8	2	2
Th CT	0	2	7	4	6

Table 53

MONITORING QUESTION B1 - CHI SQUARE 2 x 2

*	less than 50 min.	more than 50 min.
Comp ST	29	12
Comp CT	21	24

* Table notations are explained on page 31.

It was expected that both groups would respond with D or E (more than 50 minutes). The chi square value of 4.79 indicates that the expectation was not supported.

Question B2. How much time was spent per week in preparation for the lab by reading the experimental procedure?

Table 54

MONITORING QUESTION B2 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (none)	B (10-30 min)	C (30-50 min)	D (50-70 min)	E (70-120 min)
Tu ST	4	19	1	0	0
Tu CT	5	17	3	1	0
Th ST	0	16	0	1	0
Th CT	5	12	2	0	0

Table 55

MONITORING QUESTION B2 - CHI SQUARE 2 x 2

*	less than 50 min.	more than 50 min.
Comp ST	40	1
Comp CT	44	1

It was expected that both groups would respond with A, B, or C (less than 50 minutes). The chi square value of 0.00 indicates that the expectation was supported.

* Table notations are explained on page 31.

Question B3. How much time was spent per week in preparation and/or discussion of library readings?

Table 56

MONITORING QUESTION B3 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (none)	B (10-30 min)	C (30-50 min)	D (50-70 min)	E (70-120 min)
Tu ST	13	11	0	0	0
Tu CT	1	8	15	2	0
Th ST	13	2	2	0	0
Th CT	0	5	12	0	0

Table 57

MONITORING QUESTION B3 - CHI SQUARE 2 x 2

*	less than 50 min.	more than 50 min.
Comp ST	26	15
Comp CT	1	44

It was expected that the contemporary topics groups would spend some time on discussion of readings but the standard topics would not discuss the readings. The chi square value of 36.56 indicates that the expectation was supported. This confirmation of a criterion question is important evidence of a high degree of conformity with the planned treatments.

* Table notations are explained on page 31.

Question B4. How much time was spent per week introducing the experimental procedure?

Table 58

MONITORING QUESTION B4 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (none)	B (10-30 min)	C (30-50 min)	D (50-70 min)	E (70-120 min)
Tu ST	0	18	6	0	0
Tu CT	2	23	1	0	0
Th ST	2	14	1	0	0
Th CT	1	16	2	0	0

Table 59

MONITORING QUESTION B4 - CHI SQUARE 2 x 2

*	less than 50 min.	more than 50 min.
Comp ST	34	7
Comp CT	42	3

It was expected that both groups would respond with A or B (less than 30 minutes). The chi square value of 1.81 indicates that the expectation was supported.

* Table notations are explained on page 31.

Question B5. How much time was spent per week in the manipulation of the laboratory equipment, measurements, graphing and/or calculating results?

Table 60

MONITORING QUESTION B5 - RESPONSE FREQUENCY BY TREATMENT GROUP

*	A (none)	B (10-30 min)	C (30-50 min)	D (50-70 min)	E (70-120 min)
Tu ST	1	3	5	10	5
Tu CT	0	4	9	10	3
Th ST	0	2	2	4	9
Th CT	0	4	9	5	0

Table 61

MONITORING QUESTION B5 - CHI SQUARE 2 x 2

*	less than 50 min.	more than 50 min.
Comp ST	27	14
Comp CT	42	3

It was expected that the contemporary topics would spend less than 70 minutes on this activity and the standard topics group more than 70 minutes. The chi square value of 10.45 indicates that the expectation of this criteria question was supported. However, the low level of response E by the Tuesday standard topics would have implications that the class periods were cut short or more time was being spent in presentation or discussion (B3) and/or introducing the experimental procedure.

* Table notations are explained on page 31.

Summation of Treatment Monitoring Data

The treatment monitoring instrument called the Perception Questionnaire was a valuable instrument in measuring the extent of compliance with the planned experimental and control treatments. The results of the analysis on the criteria questions indicate that the treatments were followed but to a varying degree in some critical areas.

Question A3 clearly indicated that the contemporary topics groups reported using articles in preparation for the laboratory. Question A4 clearly indicated that the standard topics groups reported using reference texts in preparation for the laboratory. Questions A8 and A10 confirm that the contemporary topics group reported using lab time to discuss the readings but the standard topics groups did not. Question B3 clearly indicated that a good proportion of the lab period reported as being spent in discussion of the readings by the contemporary topics groups. Question B5 did confirm that the standard topics groups reported spending more time on the manipulation of equipment, but the Tuesday standard topics group did not report spending sufficient time at this activity.

The overall effectiveness of this questionnaire in evaluating the degree of conformity with the planned treatments is one of the highlights of this study.

Related Instructional Evaluation

In addition to this study the course under investigation during the Spring 1978 semester was also part of a program of instructional evaluation by the IDEAS System (Center for Faculty Evaluation and Development in Higher Education, 1975). This evaluation system form has some items

which are keyed to the concept of general education. The responses to these items indicated that the students were very pleased and satisfied that the course was reaching its general education purpose.

A conflict appears in that the data on the SPI and SAI show no significant change on the general education variables and the IDEAS System questionnaire showed satisfaction that general education was being accomplished.

The laboratory instructors who participated in the contemporary topics treatment sections both stated that even though the tests did not show measurable differences in the variables, the opportunity for students to read articles relating the content to contemporary situations was a beneficial addition in reaching general education objectives.

Subsequent Study and Analysis

Based on the experience of this study the author prepared a subsequent trial of the materials and measurements used for this study. It was decided to repeat the experiment in the following school year with some basic changes. There would be no special registration arrangements and all students taking the course in the fall semester would receive the standard topics approach while all students taking the course in the spring semester would receive the contemporary topics approach. The treatments were extended to cover the entire fifteen weeks of both semesters. The treatments were extended to include both physics and chemistry topics. Pretests and posttests on understanding the nature of science (SPI) and scientific attitude (SAI) were administered. The treatment monitoring perception questionnaire was completed at the end of both semesters.

Table 62 presents the mean scores on the pretest and posttest on understanding the nature of science (SPI) and scientific attitude (SAI) for both trial one (1), the original study, and trial two(2) the subsequent study.

Table 62

MEAN SCORES ON PRETEST AND POSTTEST ON UNDERSTANDING THE NATURE OF SCIENCE AND SCIENTIFIC ATTITUDE FOR BOTH TRIAL ONE AND TRIAL TWO

		Understanding the Nature of Science	Scientific Attitude
Trial 1 Standard Topics	Pretest	107.3	115.6
	Posttest	106.7	117.3
Trial 1 Contemp. Topics	Pretest	105.4	118.3
	Posttest	103.6	116.3
Trial 2 Standard Topics	Pretest	104.6	117.3
	Posttest	106.4	116.4
Trial 2 Contemp. Topics	Pretest	104.3	117.6
	Posttest	107.4	115.7

The analysis of the data of second trial proved no different than the original trial.

Table 63 presents the response frequencies on the criterion questions of the monitoring perception questionnaire for both trial one (1), the original study, and trial two (2), the subsequent study.

Table 63

RESPONSE FREQUENCY ON MONITORING INSTRUMENT CRITERION QUESTIONS FOR BOTH TRIAL ONE AND TRIAL TWO

Criterion Monitoring Questions	Response	Trial 1 Standard Topics (n=41)	Trial 1 Contemp. Topics (n=45)	Trial 2 Standard Topics (n=111)	Trial 2 Contemp. Topics (n=92)
A3	Affirmative	12	29	23	56
	Negative	29	16	88	36
A4	Affirmative	35	5	93	10
	Negative	6	40	18	82
A8	Affirmative	24	42	80	54
	Negative	17	3	31	38
A10	Affirmative	7	40	17	60
	Negative	34	5	94	32
B3	Less 50 min.	26	1	92	58
	More 50 min.	15	44	19	34
B5	Less 50 min.	27	3	82	42
	More 50 min.	14	42	19	50

The original treatment data indicated compliance with the planned treatments. The trial two (2) data showed that all laboratory sections used the standard topics approach as planned but a deviation is apparent within the contemporary topics approach. A closer inspection on a section-by-section basis indicated that one instructor with two sections containing thirty-nine students did not require readings, did not discuss the readings and used more time in the manipulation of equipment. In fact the two sections appeared to receive treatment more consistent with the traditional topics approach. This subsequent experience has assisted this author in clarifying his thoughts on the benefits of this study.

CHAPTER V

FINDINGS, DISCUSSION, AND CONCLUSIONS

The purpose of this study was to compare the different approaches to the laboratory of a general education physical science course. The comparison was based on achievement of facts and principles of physical science, understanding the nature of science, and scientific attitude. The two laboratory approaches used were (1) a contemporary topics (CT) approach which focused on reading articles and performing related experiments and (2) a standard topics (ST) which focused on text readings and performing related experiments.

Eighty-six students took part in the study. Forty-five students, twenty-fix from the Tuesday section and nineteen from the Thursday section, comprised the experimental or contemporary topics group. Forty-one students, twenty-four from the Tuesday section and seventeen from the Thursday section, comprised the control or standard topics group. All groups were enrolled in the same lecture section.

The lecture text was College Physical Science (Slabaugh and Butler, 1973). The topic outline of the lecture series with associated contemporary topics and standard topics laboratory are listed in Appendix F. Also the contemporary topics articles and the standard topics text readings are listed in Appendix F.

The lecture instructor was the investigator. The laboratory sections were taught by full-time tenured faculty of the Physical Science Department. A chemistry professor taught the contemporary topics group on Tuesday and a standard topics group on Thursday. An astronomy professor taught the contemporary topics group on Thursday and a geophysics professor taught the standard topics group on Tuesday. The

faculty members assigned to teach the laboratory were from the regularly assigned faculty members who teach these laboratory sections periodically to complete their teaching load assignments.

Each group was pretested and posttested. The following tests were used: an investigator-constructed text on the subject content of facts and principles of Physical Science; the Science Process Inventory, Form D (Welch and Pella, 1966) on the understanding of the nature of science; and the Scientific Attitude Inventory (Moore and Sutman, 1970) on scientific attitude. In addition each student was asked to complete a biographical data sheet (Appendix B) and a Treatment Perception Questionnaire (Appendix D). Also, as part of a separate project, each student completed an Idea System instructor evaluation questionnaire which contained some items relevant to general education. The Perception Questionnaire and the Idea System evaluations were written anonymously and each contained a section for written comments concerning the value of the laboratory.

The statistical technique, known as Analysis of Covariance, was used to text the main hypotheses of the study.

Findings

The analysis of data led to the following findings:

1. There was no significant difference among the various treatment groups on achievement of the subject content of facts and principles of Physical Science as measured by the investigator-constructed test.

2. There was no significant difference among the various treatment groups on the understanding of the nature of science as measured by the Science Process Inventory.
3. There was no significant difference among the various treatment groups on scientific attitude as measured by the Scientific Attitude Inventory.
4. The perception questionnaire indicated that on the six criteria questions which differentiated the treatment groups the results showed that the groups did not receive the prescribed treatment.

Discussion

Although all statistical analyses indicated that both treatments were equivalent and either could be used effectively the investigator found value in several dimensions of the study.

1. In the comparison of the treatment groups of this study the primary focus was on a measurable indication of the general education value of the laboratory approaches. Both treatments were positive on the subject content but neither treatment produced positive changes in the understanding of the nature of science or scientific attitude. Several implications can be suggested from this finding. It is possible that the course does not meet general education objectives. It is possible that the treatment period was too short to change already well-formed attitudes. Some college science teachers refer to this as a negative predisposition to science. Perhaps within this experiment the criteria instruments were

unable to measure any of the desired changes. It is possible that the treatments were not adequately different. All of these are possible and only extensive research will differentiate which factors have merit.

Of all the possible factors which might account for the lack of desired change intended by the experimental treatment the investigator would focus on four. First, the experimental design did not allow for a segment of the test sample under both treatments to omit the pretest. It was the opinion of the investigator that the sample was not sufficiently large enough to use a Solomon Four Group design. As a result the measurable changes in understanding the nature of science and scientific attitude may be muted as a test and retest reliability. A second factor would be the use of the laboratory segment of the course as the treatment difference. Since the content of the course and the course grades were dependent on the lecture, the laboratory could provide only a marginal effect. The investigator felt that the laboratory period had the advantage of small groups which would facilitate discussion and would include a variety of instructors. The third factor is a concern for the change of understanding the nature of science and/or scientific attitude within the limits of a one semester course. The results of this study indicate no change on these variables. The investigator now questions the time necessary to produce changes in these variables. Also the assumption that only the prescribed treatments influence change contribute to the opinion that longitudinal studies following

integrated experiences could be of greater value. The fourth factor of concern to the investigator deals with the level of the individual and the individual learning style. The concept that one treatment will be more effective than another in dealing with groups supposes that all individuals within each group will react essentially the same to the treatment. It is possible to divide the groups by other criterion so that the receptivity to the treatment is taken into consideration.

2. Initially it had been the intention of the investigator to allow the students to choose the contemporary topics to be investigated. The pilot studies of Fall 1976 and Spring 1977 proved this to be impractical within the situation of this study. The variety of faculty members used within this course as lab instructors required a more structured plan. As a result the topics provided by the students in the two pilot terms were developed into structured readings and exercises. The investigator still feels that with groups that have a single lecture and lab instructor the selection of topics by the students themselves will asssist in reaching general education objectives by adding a motivational factor. The perceptive questionnaire (Question A-1) did indicate more satisfaction on the part of contemporary topics groups on the relation of the topics to their personal interest.
3. Among the concerns of the investigator in developing this experiment and its design were two items that he felt were not being addressed in the studies he found in the literature.

The investigator felt that much more attention should be focused on the formation of the treatment groups and specific attention should be made to assure that the treatment groups are equivalent with regard to the criteria used to form them and all criteria variables. Considerable attention was paid to this item in the analysis of data chapter.

Also the investigator felt that he should not be an active participant in the treatment group. Many studies are conducted where the treatment is done by the investigator. This is a potential weakness of such studies for the effect on the results and limiting the treatment as a possible teacher effect. By choosing not to be a laboratory instructor for the term of the study another apparent problem appeared. The investigator had to develop a strong set of materials which clearly differentiated the treatments and a strong monitoring system. The preparation of the materials had already been achieved through the pilot terms but the investigator did not find assistance from the literature on methods of monitoring and the reporting of such monitoring. With assistance from colleagues and advisors, a suitable simple instrument was used for this study. With the assistance of the monitoring instrument the investigator was sure that the intended treatments were being applied.

4. The data from the SPI and SAI indicated no significant changes on the general education variables of this study. However, the results of the IDEAS System instructional evaluation indicated a high rating by the students on the items keyed to general education. Also the laboratory instructors involved in the

contemporary topics approach felt that the articles provided an excellent vehicle to promote scientific literacy. The apparent difference in the study results and the IDEAS results and opinions of involved faculty give rise to a question of quantitative measurements versus qualitative/opinion measurements. The fact that both the students and instructors felt strongly that they were achieving general education goals partially mutes the results of the criterion tests.

Conclusions

The findings of this study led to the following conclusions:

1. Students achieve equally well in learning the facts and principles of the subject content from both the contemporary topics and standard topics laboratory approach within an eight-week or fifteen-week treatment period.
2. Students' understanding of the nature of science as measured by the Science Process Inventory was unchanged within an eight-week or fifteen-week period by either the contemporary topics or standard topics laboratory approach.
3. Students' scientific attitude as measured by the Scientific Attitude Inventory was unchanged within an eight-week or fifteen-week period by either the contemporary topics or standard topics laboratory approach.
4. The investigator-prescribed treatments as measured by the monitoring questionnaire were acceptably followed during the eight-week period but variation from treatment occurred during the fifteen-week period.

Implications

This study, within its limits, indicates that students at Kutztown State College enrolled in Elements of Physics and Chemistry can be taught equally well with a Contemporary Topics or a Standard Topics laboratory approach. This study was conducted in order to find a way to improve the general education physical science courses at Kutztown State College. The conclusions indicate that both approaches are equally effective and therefore either approach could be selected. Other criteria should be used to decide between them such as cost, student and/or faculty perceptions. The treatment monitoring indicated that the investigator was able to measure the extent of faculty following the prescribed treatments. This study was very concerned that the investigator not be a part of the treatment faculty but that he have a close association with the treatment groups to be assured that the treatments were being applied appropriately. The treatment monitoring system is a very important aspect of this study and should be a part of all curricular studies that require different instructional methods.

Recommendations

On the basis of the experience gained through this study the investigator makes the following recommendations for studies at the college level involving general education science:

1. Future studies should be designed to determine how general education objectives can be measured effectively within the period of a semester course.
2. Future studies should attempt to correlate the quantitative data with the qualitative responses and possibly integrate the results as an evaluation of general education.

3. Future studies should focus on other variables of the student sample such as learning science literacy prior to treatment.
4. Future studies should focus on instructional areas other than the laboratory. A strong association must be structured between the course evaluation system and the treatments.
5. Future studies should use a longitudinal method taking into consideration the impact of college science courses for non-majors at various stages of the students' progress.
6. Treatment monitoring and the reporting of the monitoring results should be an integral part of all instructional studies.

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APPENDIX A

STUDENT SCORES ON CRITERIA INSTRUMENTS

TEST SCORES

CONTROL GROUP - TUESDAY STANDARD TOPICS

Student Number	S.A.T. Total	Content Pretest	Content Posttest	SPI Pretest	SPI Posttest	SAI Pretest	SAI Posttest
1	1220	33	60	112	113	105	100
2	780	32	54	115	116	138	142
3	840	24	38	107	113	108	116
4	1010	32	59	111	115	121	133
5	820	24	39	114	105	111	116
6	1010	27	54	111	108	139	128
7	970	27	53	107	105	118	127
8	1000	25	47	115	113	142	147
9	860	34	60	109	105	132	128
10	1030	28	40	114	103	120	117
11	810	34	46	109	112	117	107
12	860	33	53	107	112	110	114
13	1060	30	59	109	109	118	111
14	820	26	51	104	109	113	128
15	840	22	36	107	110	110	97
16	1140	37	55	112	95	129	129
17	710	21	46	113	118	115	123
18	430	18	23	83	92	89	94
19	1100	30	57	107	100	104	89
20	1070	28	53	105	104	109	106
21	860	32	48	112	109	108	105
22	940	26	54	115	111	104	95
23	560	23	38	99	97	97	98
24	940	28	65	115	116	107	110

TEST SCORES

CONTROL GROUP - THURSDAY STANDARD TOPICS

Student Number	S.A.T. Total	Content Pretest	Content Posttest	SPI Pretest	SPI Posttest	SPI Pretest	SPI Posttest
1	1060	48	59	108	116	103	107
2	1310	24	60	119	117	132	134
3	650	28	60	107	107	127	121
4	780	28	44	103	105	115	134
5	710	24	40	97	74	89	94
6	1040	32	49	106	118	109	111
7	860	26	46	98	111	111	129
8	860	19	40	110	109	127	128
9	1170	25	54	110	112	127	140
10	990	29	49	106	97	98	93
11	810	28	50	103	86	117	133
12	970	37	67	120	110	139	131
13	980	31	43	88	115	114	121
14	830	17	36	106	108	109	107
15	990	24	43	107	109	111	115
16	690	28	38	88	85	122	119
17	1090	37	62	113	107	136	131

TEST SCORES
EXPERIMENTAL GROUP - TUESDAY CONTEMPORARY TOPICS

Student Number	S.A.T. Total	Content Pretest	Content Posttest	SPI Pretest	SPI Posttest	SAI Pretest	SAI Posttest
1	890	27	47	102	107	113	116
2	1070	35	56	119	120	117	120
3	910	28	56	115	124	106	122
4	1120	33	59	110	118	121	123
5	829	24	59	103	92	123	109
6	1100	39	66	117	122	123	135
7	740	31	47	98	106	110	116
8	1180	32	59	114	117	134	130
9	700	32	54	110	101	112	114
10	810	26	36	106	110	108	102
11	890	25	42	103	102	116	115
12	970	33	53	112	108	114	114
13	1090	35	62	113	107	129	113
14	750	16	39	101	106	122	105
15	630	17	35	92	91	100	97
16	820	25	39	105	100	121	110
17	540	20	51	78	68	102	113
18	1050	38	43	117	110	133	138
19	670	24	40	109	101	113	114
20	750	15	42	100	90	118	114
21	530	22	33	98	00	116	129
22	1120	38	63	117	120	134	123
23	1210	28	60	121	116	137	112
24	950	23	55	110	102	117	119
25	920	35	52	107	116	125	119
26	720	22	50	87	111	120	112

TEST SCORES

EXPERIMENTAL GROUP - THURSDAY CONTEMPORARY TOPICS

Student Number	S.A.T. Total	Content Pretest	Content Posttest	SPI Pretest	SPI Posttest	SAI Pretest	SAI Posttest
1	840	19	36	99	98	108	84
2	1090	28	39	111	101	120	117
3	960	35	60	108	103	109	115
4	730	24	45	100	70	117	118
5	770	16	40	103	108	118	96
6	1350	45	67	117	121	137	140
7	810	16	39	97	103	128	122
8	1110	31	57	112	112	122	114
9	780	24	52	100	84	120	103
10	990	24	55	106	104	120	122
11	1010	18	50	112	101	105	108
12	1170	31	60	112	117	111	121
13	910	23	58	101	96	115	115
14		29	57	108	83	107	119
15	950	21	44	101	106	128	129
16		27	30	91	100	116	120
17	610	20	45	97	100	128	131
18	880	29	39	102	88	112	108
19	790	28	40	104	101	110	117

APPENDIX B

STUDENT BIOGRAPHICAL DATA

BIOGRAPHICAL DATA

CONTROL GROUP - TUESDAY STANDARD TOPICS

Student Number	Parental Education	Parental Occupation	College Curriculum	Year in College	H.S. Science Units	H.S. Science Points
1	High School	Blue Collar	Lib. Arts/BS	2	3	9
2	High School	Blue Collar	Lib. Arts/BA	4	3	9
3	High School	White Collar	Teacher Ed.	4	3	8
4	High School	White Collar	Lib. Arts/BA	2	3	6
5	College-4 Yr.	Professional	Teacher Ed.	2	2	4
6	College-4 Yr.	Professional	Lib. Arts/BS	3	3	7
7	High School	Blue Collar	Teacher Ed.	2	4	14
8	College-4 Yr.	Professional	Art	1	2	6
9	High School	Blue Collar	Lib. Arts/BA	1	4	10
10	College-4 Yr.	Professional	Teacher Ed.	1	2	6
11	High School	White Collar	Lib. Arts/BA	2	2	5
12	High School	Blue Collar	Art	1	4	12
13	High School	Blue Collar	Teacher Ed.	2	4	13
14	High School	Blue Collar	Lib. Arts/BA	2	3	8
15	College- 2 Yr.	White Collar	Lib. Arts/BA	4	2	5
16	High School	Blue Collar	Teacher Ed.	1	4	13
17	High School	White Collar	Teacher Ed.	2	2	7
18	High School	Blue Collar	Teacher Ed.	2	3	5
19	High School	Blue Collar	Lib. Arts/BA	2	4	11
20	High School	Blue Collar	Teacher Ed.	4	4	10
21	High School	White Collar	Lib. Arts/BA	1	3	5
22	High School	White Collar	Teacher Ed.	2	3	12
23	High School	Blue Collar	Teacher Ed.	1	1	2
24	High School	Blue Collar	Teacher Ed.	2	4	14

BIOGRAPHICAL DATA

EXPERIMENTAL GROUP - TUESDAY CONTEMPORARY TOPICS

Student Number	Parental Education	Parental Occupation	College Curriculum	Year in College	H.S. Science Units	H.S. Science Points
1	College-2 Yr.	White Collar	Teacher Ed.	2	3	6
2	College-4 Yr.	Professional	Teacher Ed.	4	2	7
3	College-4 Yr.	Professional	Lib. Arts/BS	3	2	7
4	College-4 Yr.	Professional	Lib. Arts/BA	1	4	12
5	College-2 Yr.	Blue Collar	Teacher Ed.	2	3	12
6	High School	Blue Collar	Teacher Ed.	1	4	14
7	College-2 Yr.	White Collar	Teacher Ed.	2	3	8
8	High School	Blue Collar	Teacher Ed.	2	2	8
9	High School	Blue Collar	Teacher Ed.	1	3	8
10	High School	White Collar	Teacher Ed.	3	3	8
11	College-4 Yr.	White Collar	Teacher Ed.	1	2	5
12	College-4 Yr.	White Collar	Lib.Arts/BA	3	3	8
13	High School	Blue Collar	Lib.Arts/BS	1	4	14
14	High School	Blue Collar	Teacher Ed.	2	2	4
15	High School	Blue Collar	Teacher Ed.	1	3	10
16	High School	Blue Collar	Teacher Ed.	3	3	9
17	High School	Blue Collar	Lib. Arts/BA	1	4	14
18	College-4 Yr.	Professional	Lib. Arts/BA	2	4	10
19	High School	Blue Collar	Teacher Ed.	2	2	6
20	High School	Blue Collar	Teacher Ed.	2	4	13
21	College-4 Yr.	Professional	Teacher Ed.	2	2	5
22	College-4 Yr.	Professional	Lib. Arts/BA	2	4	12
23	College-4 Yr.	Professional	Lib. Arts/BS	4	3	9
24	High School	Blue Collar	Teacher Ed.	3	3	8
25	High School	Blue Collar	Lib. Arts/BS	3	4	7
26	College-4 Yr.	Professional	Teacher Ed.	2	3	9

BIOGRAPHICAL DATA

CONTROL GROUP - THURSDAY STANDARD TOPICS

Student Number	Parental Education	Parental Occupation	College Curriculum	Year in College	H.S. Science Units	H.S. Science Points
1	High School	Blue Collar	Teacher Ed.	2	4	14
2	High School	Blue Collar	Teacher Ed.	1	4	15
3	High School	Blue Collar	Lib.Arts/BS	2	3	9
4	College-2 Yr.	White Collar	Teacher Ed.	1	4	12
5	High School	Blue Collar	Teacher Ed.	1	3	9
6	High School	Blue Collar	Teacher Ed.	2	4	13
7	High School	Blue Collar	Lib. Arts/BA	2	4	11
8	College-4 Yr.	White Collar	Teacher Ed.	1	3	8
9	High School	Blue Collar	Teacher Ed.	1	2	8
10	High School	Blue Collar	Teacher Ed.	2	3	7
11	College-2 Yr.	White Collar	Teacher Ed.	2	4	11
12	High School	Blue Collar	Lib.Arts/BA	2	3	8
13	High School	White Collar	Art	2	3	9
14	College-4 Yr.	White Collar	Teacher Ed.	2	4	13
15	College-4 Yr.	White Collar	Lib. Arts/BA	2	3	8
16	High School	White Collar	Lib. Arts/BA	3	2	6
17	College-2 Yr.	White Collar	Lib. Arts/BA	2	2	6

BIOGRAPHICAL DATA

EXPERIMENTAL GROUP - THURSDAY CONTEMPORARY TOPICS

Student Number	Parental Education	Parental Occupation	College Curriculum	Year in College	H.S. Science Units	H.S. Science Points
1	College-4 Yr.	Professional	Teacher Ed.	2	4	8
2	College-4 Yr.	Professional	Lib. Arts/BA	2	3	6
3	High School	Blue Collar	Lib. Arts/BS	1	4	15
4	College-4 Yr.	Professional	Teacher Ed.	1	3	10
5	High School	Blue Collar	Teacher Ed.	1	3	6
6	College 2 Yr.	White Collar	Teacher Ed.	1	4	15
7	High School	Blue Collar	Teacher Ed.	2	4	12
8	College-4 Yr.	Professional	Teacher Ed.	2	4	16
9	High School	Blue Collar	Teacher Ed.	1	4	10
10	College-2 Yr.	White Collar	Teacher Ed.	1	2	8
11	College-4 Yr.	Professional	Teacher Ed.	2	3	9
12	College-2 Yr.	White Collar	Teacher Ed.	1	3	11
13	College-4 Yr.	Professional	Lib. Arts/BS	2	3	9
14	High School	White Collar	Lib. Arts/BA	4	2	8
15	High School	White Collar	Lib. Arts/BA	2	3	10
16	High School	Blue Collar	Teacher Ed.	1	3	7
17	High School	White Collar	Teacher Ed.	1	4	10
18	High School	White Collar	Teacher Ed.	2	4	10
19	High School	Blue Collar	Lib. Arts/BS	2	4	12

APPENDIX C

INVESTIGATOR-CONSTRUCTED SUBJECT CONTENT TESTS

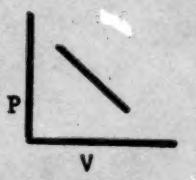
KUTZTOWN STATE COLLEGE
Kutztown, Pennsylvania

Physical Science Department

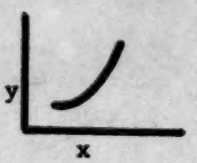
Phy 10 - SUBJECT CONTENT PRETEST - SPRING 1978

Name _____ SS # _____ Score _____

____ 1. A scientific hypothesis is (a) a law of nature (b) a diagram showing the paths taken by the planets (c) a proposed explanation for observations make on some aspect of the physical world (d) a statement of experimental results.

____ 2. 

Which of the following expressions best represents the relationship between the graphed variables?
(a) P $\propto$ V (b) P = k V (c) P $\propto$ 1/V (d) P = k/V

____ 3. 

Which of the following expressions best represents the relationship between the graphed variables?
(a) y $\propto$ x (b) y = k x (c) y $\propto$ 1/x (d) y = k/x

____ 4. A scalar quantity: (a) is an arrow, (b) has magnitude only, (c) has direction only, (d) has magnitude and direction, (e) is more complex to manipulate than a vector quantity.

____ 5. An example of a vector quantity is (a) mass (b) speed (c) temperature (d) color (e) none of these.

____ 6. Which of the following measurements is smallest? (a) 50 grams (b) 50 kilograms (c) 50 micrograms (d) 50 milligrams (e) 50 centigrams.

____ 7. The metric unit of mass is (a) pound (b) gram (c) newton (d) meter.

____ 8. Which of the following units is used in both metric and English systems? (a) liter (b) grams (c) foot (d) second (e) mile

___ 9. An object has a density of 0.75 gms/cm^3. How much of its volume is above water? (a) 50% (b) 65% (c) 75% (d) cannot tell from information given

___ 10. Two cars travel along the same road in the same direction from the same starting place. One car maintains a speed of 50 mi/hr. and the other car 60 mi/hr., but the second car starts 1 hour later. How many hours will it take for the second car to overtake the first car? (a) 2 (b) 3 (c) 4 (d) 5

___ 11. An airplane travels at constant speed a distance of 160 miles in a time of ½ hour. Its speed is (a) 80 mi/hr (b) 160 mi/hr (c) 320 mi/hr (d) 640 mi/hr.

___ 12. In successive seconds an object moves 3 ft., 6 ft., 9 ft., 12 ft., etc. This is an example of: (a) constant velocity (b) constant motion (c) accelerated motion (d) uniformly accelerated motion (e) constant speed.

___ 13. An object is accelerated at 20 ft/sec^2 for 15 seconds. The final velocity will be (a) 1.25 ft/sec (b) 150 ft/sec (c) 300 ft/sec (d) 450 ft/sec (e) none of these.

___ 14. Neglecting friction, if a Cadillac and Volkswagon start rolling down the hill together. The heavier Cadillac will get to the bottom (1) before the Volkswagon (2) after the Volkswagon (3) the same time as the Volkswagon.

___ 15. A sheet of paper can be withdrawn from under a bottle of milk without toppling if the paper is jerked out quickly. This is an example of (1) inertia (2) potential energy (c) acceleration (4) action - reaction.

___ 16. If the acceleration of an object is constant, so must be: (a) its speed (b) its velocity (c) its direction (d) the forces in action on it (e) none of the above.

___ 17. If we know the magnitude and direction of the force exerted on a body of given mass, Newton's second law of motion permits us to calculate its (a) position (b) speed (c) velocity (d) acceleration.

___ 18. A ball player hits a ball with a bat. Consider the action force to be that of the bat against the ball. Then the reaction force is the (a) air resistance on the ball (b) weight of the ball (c) ball against the bat (d) grip of the player's hands on the bat (e) friction of the ground against the player's feet.

___ 19. A force gives a 100-lb. weight an acceleration of 20 ft/sec^2. The same force would give a weight of 1,000 lb. an acceleration of (a) 2 ft/sec^2 (b) 5 ft/sec^2 (c) 10 ft/sec^2 (d) 200 ft/sec^2.

____ 20. The Earth"s gravitational attraction for an object is called (a) weight (b) mass (c) force (d) inertia (e) acceleration.

____ 21. An object has a weight of 180 pounds on earth. What will be its weight on a planet with twice the mass and three times the radius? (a) 180# (b) 90# (c) 360# (d) 40# (e) none of these

____ 22. As a car rounds a curve, the centripetal force is determined by the expression $F=m\ V^2/R$. If the speed of the car is doubled, the force will be (a) one-half (b) one-fourth (c) doubled (d) four times as great.

____ 23. A 100 lb. crate is pushed across a 10 ft. dock by a force of 20 lb. The work done is (a) 1,000 ft-pound (b) 1,200 ft-pound (c) 200 ft-pound (d) 300 ft-pound.

____ 24. As an object is thrown into the air (vertically), the work done in throwing it is stored in the form of (a) friction (b) velocity (c) energy (d) height (e) none of these.

____ 25. A 2,000 lb. car and a 4,000 lb. car are each hoisted to the same elevation in a gas station. Raising the heavier car required (a) less energy (b) as much energy (c) twice as much energy (d) four times as much energy (e) more than four times as much as energy.

____ 26. If one doubles the speed of a moving body, one also doubles its (a) acceleration (b) momentum (c) kinetic energy (d) potential energy (e) inertia.

____ 27. An object moves its kinetic energy is determined by the expression $KE = \frac{1}{2}\ mv^2$. If the velocity of the object is doubled, the kinetic energy is (a) doubled (b) one-half (c) four times (d) one-fourth as great.

____ 28. The average kinetic energy of the molecules in a body is called (a) light (b) heat (c) temperature (d) potential energy (e) mechanical energy

____ 29. Heat is most closely related to (a) temperature (b) energy (c) momentum (d) friction.

____ 30. The amount of heat necessary to raise 1 pound of water 1 degree Fahrenheit is a (a) kilocalorie (b) calorie (c) BTU (d) joule

____ 31. Two bars of lead, one twice as heavy as the other, are heated to a temperature of 200° C. The heavy bar (a) contains half as much heat as the lighter bar (b) contains the same amount of heat as the lighter bar (c) contains twice as much heat.

as the lighter bar (d) many contain more or less heat than the lighter bar, depending upon the precise shape of the bars.

____ 32. In a longitudinal wave (a) the compressions and refractions travel in the same direction (b) the compressions and refractions travel in opposite directions (c) neither: only traverse waves have compressions and refractions.

____ 33. The distance between identical points on two successive waves from a vibrating object is called: (a) pitch (b) frequency (c) amplitude (d) quality (d) wave length.

____ 34. Of the following properties of a wave, the one that is independent of the others is its (a) velocity (b) amplitude (c) wave length (d) frequency.

____ 35. Sound waves cannot travel in which of the following: (a) air (b) under water (c) in steel (d) in a vacuum (e) sound can travel in all of the above.

____ 36. The loudness of a sound has most to do with (a) frequency (b) wave length (c) temperature (d) amplitude (e)velocity.

____ 37. Beats occur because of (a) refraction (b) reflection (c) interference (d) the Doppler effect.

____ 38. An automobile sounding its horn is moving away from an observer. The pitch of the horn's sound relative to its normal pitch is: (a) higher (b) lower (c) the same (d) higher or lower depending upon the exact frequency.

____ 39. The speed of sound having a frequency of 256 cycles/sec compared with the speed of sound having a frequency of 512 cycles/sec is (a) half as great (b) the same (c) twice as great (d) four times great.

____ 40. The intensity of a sound transmitted by a loudspeaker was measured 1 ft. from the speaker. The intensity of that sound, if measured 4 ft. from the speaker would be: (a) 4 times as loud (b) ¼ times as loud (c) 16 times as loud (d) 1/16 as loud (e) 5 times as loud.

____ 41. Which of the following does <u>not</u> consist of electromagnetic waves? (a) x-rays (b) radar waves (c) sound waves (d) infrared waves

____ 42. A phenomenon that can be explained only if light consists of waves is (a) reflection (b) refraction (c) interference (d) the ether.

____ 43. The property of light waves that leads to the phenomenon of color is their (a) velocity (b) amplitude (c) quality (d) wave length.

____ 44. A pencil partially submerged in a glass of water appears "broken" because of: (a) interference (b) diffraction (c) polarization (d) refraction (e) absorption.

____ 45. Lasers emit light by the process of (a) scattering (b) incandescence (c) flourescence (d) reflection (e) excitation.

____ 46. The intensity of electromagnetic waves from their source decreases inversely with: (a) the distance (b) the square of the distance (c) the cube of the distance (d) the wave length of the waves.

____ 47. The color of an opague object is determined by the light which is (a) reflected (b) absorbed (c) transmitted (d) all of the above.

____ 48. A piece of green cloth (a) reflects all colors (b) absorbs all colors (c) reflects all colors but green (d) absorbs all colors but green (e) absorbs only red light.

____ 49. A red dress when viewed in a yellow light appears (a) green (b) yellow (c) red (d) black.

____ 50. A blue dress when viewed in a yellow light appears (a)blue (b) yellow (c) red (d) black.

____ 51. Constructive and destructive interfernce may take place in the case of (a) sound waves (b) water waves (c) light waves (d) all of the above (e) none of the above.

____ 52. Light and color are related in the same manner as sound and: (a) frequency (b) pitch (c) wave length (d) amplitude (e) intensity.

____ 53. From the following, which property of a light wave is not characteristic of a sound wave? (a) wave length (b) frequency (c) interference (d) polarization (e) Doppler shift.

____ 54. Which of the following is a property of a <u>light wave</u> but <u>not</u> of a <u>sound wave</u>? (a) frequency (b) wave length (c) polarization (d) interference (e) Doppler shift.

____ 55. Gamma radiation is most similar to which of the following: (a) sound waves (b) x-rays (c) alpha particles (d) protons (e) electrons.

____ 56. An alpha particle is represented by which of the following symbols?

(a) $_{2}He^{4}$ (b) $_{1}H^{1}$

(c) $_{1}H^{2}$ (d) $_{7}N^{14}$

____ 57. The part of an atom having no net electrical charge is (a) proton (b) electron (c) neutron (d) ion (e) isotope.

____ 58. Electrically neutral objects have (a) an excess of electrons (b) an excess of protons (c) no charge (d) equal number of electrons and protons.

____ 59. An atom os silicon that is positively charged has: (a) an excess of protons (b) an excess of electrons (c) a deficiency of electrons (d) a deficiency of protons (e) an excess of neutrons.

____ 60. With respect to electricity, which of the following substances is not classified with the others? (a) copper (b) glass (c) plastic (d) wool (e) paraffin

____ 61. A negatively charged body is brought near a negatively charged electroscope. The electroscope is grounded and the negatively charged body is withdrawn. The charge on the electroscope will be: (a) positive (b) negative (c) neutral (d) increased (e) unchanged.

____ 62. An electroscope has a positive charge. When a body having a charge is brought near, the leaves diverge further. The sign of the charge body is (a) neutral (b) positive (c) negative (d) unknown.

____ 63. The Modern Unit of electric charge is the (a) electron volt (b) coulomb (c) newton per square meter (d) ion.

____ 64. Magnetism is most closely related to (a) electricity (b) sound (c) radiation (d) wave length (e) light.

____ 65. In order to move an electric charge against a positively charged electric field, which of the following must be done? (a) a dry cell discharged (b) work (c) a circuit must be moved (d) a generator must be disconnected (3) temperature must be increased.

____ 66. A positive and negative charge are initially 4 cm apart. When they are moved closer together so that they are now only 1 cm apart, the force between them is (a) 4 times smaller than before (b) 4 times larger than before (c) 8 times larger than before (d) 16 times larger than before.

____ 67. Electrical current can be most closely associated with the concept of (a) potential energy (b) velocity (c) conservation of mass (d) inertia.

____ 68. A device which transforms electric energy to mechanical energy is (a) a generator (b) a motor (c) a transformer (d) a magnet.

____ 69. The quantity of electric charge that flows per second through a circuit depends on: (a) distance (b) heat (c) resistance (d) potential energy (e) kinetic energy.

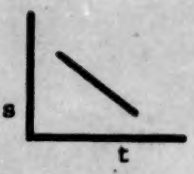
____ 70. The current in a 40-watt volt electric light bulb is (a) 1/3 amp. (b) 3 amp. (c) 30 amp. (d) 4,800 amp.

KUTZTOWN STATE COLLEGE
Kutztown, Pennsylvania

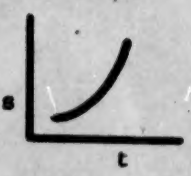
PHYSICAL SCIENCE DEPARTMENT
PHYSICS 10 - Spring 1978 - Physics Test 1

Name _____ SS # _____ Score _____

___ 1. An example of a vector quantity is:
(a) mass (b) speed (c) temperature (d) color (e) force

___ 2. 

Which of the following expressions best represents the relationship between the graphed variables?
(a) $s \propto t$ (b) $s = k\ t$
(c) $s \propto 1/t$ (d) $s = k/t$

___ 3. 

Which of the following expressions best represents the relationship between the graphed variables?
(a) $s \propto t$ (b) $s = k\ t$
(c) $s \propto 1/5$ (d) $s = k/t$

___ 4. The volume of a certain liquid was found to be 25 cm^3. Its mass may have been:
(a) 25 pounds (b) 25 micrograms (c) 2,500 ounces
(d) 25 grams (e) 25 ml.

___ 5. A vector quantity: (a) is an arrow (b) has magnitude only (c) has direction only (d) has magnitude and direction (e) is more complex to manipulate than a vector quantity.

___ 6. An example of a scalar quantity is (a) pound (b) gram (c) newton (d) meter.

___ 7. The metric unit of force is (a) pound (b) gram (c) newton (d) meter.

___ 8. Which of the following units is used in both metric and English systems? (a) liter (b) grams (c) foot (d) second (e) mile

___ 9. The length of an unsharpened pencil is about: (a) 19 cm (b) 19 mm (c) 19 m (d) 19 inches (e) 19 km.

___ 10. A man has a still water swimming rate of 8 ft/sec. If swimming in a stream of current 2 ft/sec., how long will it take him to swim 60 feet upstream, turn and return?
(a) 10 sec. (b) 20 sec. (c) 15 sec. (d) 16 sec. (e)none of these

___ 11. An airplane travels at constant speed a distance of 80 miles in a time of ½ hour. Its speed is (a) 80 mi/hr. (b) 160 mi/hr. (c) 320 mi/hr. (d) 640 mi/hr.

___ 12. In successive seconds an object moves 3 ft., 6 ft., 9 ft., 12 ft., etc. This is an example of: (a) constant velocity (b) constant motion (c) accelerated motion (d) uniformly accelerated motion (e) constant speed.

___ 13. An object is accelerated at 10 ft/sec^2 for 15 seconds. The final velocity will be (a) 1.50 ft/sec. (b) 150 ft/sec. (c) 300 ft/sec. (d) 450 ft/sec. (e) none of these.

___ 14. When a body is accelerated, (a) its velocity always changes (b) its speed always changes (c) its direction always changes (d) it falls toward earth.

___ 15. The force required to maintain a body at constant speed in free space is equal to (a) the mass of the body (b) zero (c) the weight of the body (d) the force required to stop it (e) none of these.

___ 16. With a quick pull, you can withdraw a sheet of paper from under a glass of water without spilling the water. This phenomenon is an illustration of (a) lack of friction (b) acceleration (c) velocity (d) inertia.

___ 17. If we know the magnitude and direction of the force exerted on a body of given mass, Newton's second law of motion permits us to calculate its (a) position (b) speed (c) velocity (d) acceleration.

___ 18. Disregarding air resistance, falling objects fall at constant (a) distances of 16 ft. each successive second (b) velocity (c) speed (d) acceleration (e) all of the above.

___ 19. Using the expression $S = \frac{1}{2} gt^2$ (distance moved by a falling body), if we increase the time 3 fold, the distance moved is (a) increased by 3 (b) decreased to 1/3 (c) increased by 6 (d) increased by 9.

___ 20. A force gives a 200 lb. weight an acceleration of 20 ft/sec^2. The same force would give a weight of 1,000 lbs. an acceleration of (a) 2 ft/sec^2 (b) 4 ft/sec^2 (c) 5 ft/sec^2 (d) 200 ft/sec^2.

___ 21. The Earth's gravitational attraction for an object is called (a) weight (b) mass (c) force (d) inertia (e)acceleration.

___ 22. If a man weighs 160# on Earth, what would he weigh on a planet of twice the mass of Earth? (a) 160# (b) 320# (c) 80# (d) 40# (e) none of these

___ 23. A 200 lb. crate is pushed across a 10 ft. deck by a force of 20 lbs. The work is (a) 2,000 ft-pound (b) 2,400 ft-pound (c) 200 ft-pound (c) 3,000 ft-pound.

___ 24. As an object is thrown into the air (vertically), the work done in throwing it is stored in the form of (a) friction (b) velocity (c) energy (d) height (e) none of these.

___ 25. From the following, which quantity increases the inertia a moving object contains: (a) distance from earth (b) direction of motion (c) frictional resistance (d) shape of object (e) mass of object.

___ 26. If an object is lifted 10 ft. it has potential energy. If it is lifted 20 ft., it has (a) less energy (b) as much energy (c) twice as much energy (d) four times as much energy (e) more than four times as much energy.

___ 27. An object moves its kinetic energy is determined by the expression $KE = \frac{1}{2} mv^2$. If the velocity of the object is doubled, the kinetic energy will be (a) doubled (b) one-half (c) four times (d) one-fourth as great.

___ 28. The part of an atom having no net electrical charge is (a) proton (b) electron (c) neutron (d) ion (e) isotope.

___ 29. Static electricity is generally produced by: (a) osmosis (b) induction (c) etheral fluid (d) friction (e) batteries.

___ 30. Electrically charged negative objects have (a) an excess of electrons (b) a deficiency of protons (c) equal number protons and neutrons (d) a deficiency of electrons.

___ 31. Electrically neutral objects have (a) an excess of electrons (b) an excess of protons (c) no charge (d) equal number of electrons and protons.

___ 32. Two like charges of 2 statcoulombs each exert a force of F. If each charge is doubled, what will be the new force between, all other things being equal? (a) ½ old force (b) twice old force (c) 4 times old force (d) ¼ old force.

___ 33. An electroscope has a positive charge. When a body having a charge is brought near, the leaves diverge further. The sign of the charge body is (a) neutral (b) positive (c) negative (d) unknown.

___ 34. An electroscope is a device (a) for generating electric charge (b) for producing sparks (c) for determining the magnitude of a charge (d) that magnifies electrons so that they are visible.

___ 35. A negatively charged body is brought near a negatively charged electroscope. The electroscope is grounded and the negatively charged body is withdrawn. The charge on the electroscope will be: (a) positive (b) negative (c) neutral (d) increased (e) unchanged.

___ 36. The Modern Unit of electric charge is the (a) electron volt (b) coulomb (c) newton per square meter (d) ion.

___ 37. Current electricity is the flow of: (a) protons (b) electrons (c) an electric field (d) a magnetic field (e) neutrons.

___ 38. A device which transforms electric energy to mechanical energy is (a) a generator (b) a motor (c) a transformer (e) a magnet.

___ 39. The quantity of electric charge that flows per second through a circuit depends on: (a) distance (b) heat (c) resistance (d) potential energy (e) kinetic energy.

___ 40. The current flowing in a 60-watt, 120-volt electric light bulb is: (a) 2 amperes (b) 180 amperes (c) 60 amperes (d) 720 amperes (e) 0.5 amperes.

___ 41. Determine the cost of operating a 500-watt appliance for 30 minutes at 7¢ per kilowatt-hour. (a) $10.50 (b) $1.05 (c) 1.75¢ (d) 17.5¢ (e) none of these.

___ 42. Electrical current can be most closely associated with the concept of (a) potential energy (b) velocity (c) conservation of mass (d) inertia.

___ 43. Magnetism is most closely related to (a) electricity (b) sound (c) radiation (d) wave motion (e) light.

___ 44. In order to move an electric charge against a positively charged electric field, which of the following must be done? (a) a dry cell discharged (b) work (c) a circuit must be broken (d) a generator must be disconnected (e) temperature must be increased.

___ 45. An iron rod is called magnetic when (a) there is a net spin of its electrons in the same direction (b) it has more positive ions at one end and negative ones at the other (c) its atoms are lined up with + charge at one end and a - charge at the other (d) its electrons have stopped moving and are pointing in the same direction.

___ 46. In a longitudinal wave (a) the compressions and refractions travel in the same direction (b) the compressions and refractions travel in opposite directions (c) neither: only transverse waves have compressions and refractions.

____ 47. The distance between identical points on two successive waves from a vibrating object is called: (a) pitch (b) frequency (c) amplitude (d) quality (e) wave length.

____ 48. Sound waves are not transmitted by: (a) gases (b)liquids (c) solids (d) a vacuum (e) glass.

____ 49. The amplitude of a sound wave determines its (a) loudness (b) pitch (c) reverberation (d) interference.

____ 50. Sound interference is evidenced in (a) beats (b) resonance (c) refraction (d) echoes (e) the Doppler effect.

____ 51. The intensity of a sound transmitted by a loudspeaker was measured 4 ft. from the speaker. The intensity of that sound, if measured, 1 ft. from the speaker would be: (a) 4 times as loud (b) ¼ as loud (c) 16 times as loud (d) 1/16 as loud (e) 5 times as loud.

____ 52. A phenomenon that can be explained only if light consists of waves is (a) reflection (b) refraction (c) interference (d) the other.

____ 53. The frequency of an electromagnetic wave is inversely related to its: (a) velocity (b) speed (c) color (d) wave length (e) energy.

____ 54. An oar partially immersed in water appears "broken" because of (a) refraction (b) diffraction (c) polarization (d) interference (e) absorption.

____ 55. A laser emits light by the process of (a) excitation (b) incandescence (c) scattering (d) reflection.

____ 56. The intensity of electromagnetic waves from their source decreases inversely with: (a) the distance (b) the square of the distance (c) the cube of the distance (d) the frequency of the waves (e) the wave length of the waves.

____ 57. The color of an opaque object is determined by the light which is (a) reflected (b) absorbed (c) transmitted (d) all of the above.

____ 58. A piece of green cloth (a) reflects all colors (b) absorbs all colors (c) reflects all colors but green (d) absorbs all colors but green (e) absorbs only red light.

____ 59. A red dress when viewed in a cyan light appears (a) green (b) yellow (c) red (d) black.

____ 60. Constructive and destructive interference may take place in the case of (a) sound waves (b) water waves (c) light waves (d) all of the above (e) none of these.

___ 61. From the following, which property of a light wave is not characteristic of a sound wave? (a) wave length (b) frequency (c) interference (d) polarization (e) Doppler shift.

___ 62. Light and color are related in the same manner as sound and (a) frequency (b) pitch (c) wave length (d) amplitude (e) intensity.

___ 63. To which of the following is light not similar? (a) x-ray (b) gamma rays (c) TV waves (d) radio waves (e) sound waves.

___ 64. Gamma radiation is most similar to which of the following: (a) sound waves (b) x-rays (c) alpha particles (d) protons (e) electrons.

___ 65. An alpha particle is represented by which of the following symbols?

(a) $_2He^4$ (b) $_1H^1$ (c) $_1H2$ (d) $_7N^{14}$

___ 66. The difference between x-rays and radio waves is (a) their charge (b) their mass (c) their frequency (d) the medium through which they travel (e) the speed at which they travel.

___ 67. Heat is most closely related to (a) temperature (b) energy (c) momentum (d) friction.

___ 68. The average kinetic energy of the molecules in a body is called: (a) light (b) heat (c) temperature (d) potential energy (e) mechanical energy.

___ 69. The amount of heat necessary to raise 1 gram of water 1 degree coleius is (a) kilocalorie (b) calorie (c) BTU (e) joule.

___ 70. Two bars of lead, one twice as heavy as the other, are heated to a temperature of 200°C. The heavy bar
(a) contains half as much heat as the lighter bar
(b) contains the same amount of heat as the lighter bar
(c) contains twice as much heat as the lighter bar
(d) may contain more or less heat than the lighter bar, depending upon the precise shape of the bars.

APPENDIX D

STUDENT PERCEPTION QUESTIONNAIRE

KUTZTOWN STATE COLLEGE
Kutztown, Pennsylvania

Physical Science Dept.

PHY 010L - Student Perception Questionnaire Section _____
Spring 1978

PART A: The following questions are intended to measure the extent of the difference between the two laboratory methods. Please answer the questions using the following scale - - - -

(a)	always	(100%)
(b)	frequently	(60-90%)
(c)	intermittently	(40-60%)
(d)	occasionally	(10-35%)
(e)	never	(0%)

TO WHAT EXTENT . . . . . .

_____ A1 . . . . did the topics of the readings relate to your personal interest?

_____ A2 . . . . did the experiments relate to your personal interest?

_____ A3 . . . . did you use articles in preparation for the laboratory period?

_____ A4 . . . . did you use reference texts in preparation for the laboratory period?

_____ A5 . . . . did you use your text in preparation for laboratory?

_____ A6 . . . . did your text relate to the topic of the laboratory experiment?

_____ A7 . . . . did your text relate to the topics of the lecture series?

_____ A8 . . . . did the laboratory instructor presentation and/or discussion relate to the readings?

_____ A9 . . . . did the laboratory instructor presentation and/or discussion relate to the experiments?

_____ A10. . . . did the laboratory instructor adequately cover the readings?

_____ A11. . . . did the laboratory instructor adequately cover the experiments?

_____ A12. . . . did the laboratory instructor adequately collect the reading reports?

_____ A13. . . . did the library readings relate to the experiment?

_____ A14. . . . did the library readings relate to the topics of the lectures?

PART B: The following questions are intended to measure how the time of the laboratory was spent. Please answer the questions using the following scale . . . .

(a) none
(b) 10-30 minutes
(c) 30-50 minutes
(d) 50-70 minutes
(e) 70-120 minutes

HOW MUCH TIME WAS SPENT PER WEEK . . . .

_____ B1 . . . . in preparation for the laboratory by reading in the library and writing reports?

_____ B2 . . . . in preparation for the laboratory by reading the experimental procedure?

_____ B3 . . . . in presentation and/or discussion of library readings?

_____ B4 . . . . in introducing the experimental procedure?

_____ B5 . . . . in the manipulation of the laboratory equipment, measurements, graphing, and/or calculating results?

APPENDIX E

BIOGRAPHICAL DATA FORM

KUTZTOWN STATE COLLEGE
Physical Science Department
Biographical Data - Phy 10 - Spring 1978

Name _____ SS # _____
Last First MI

High School Science

1st Course _____ Grade _____

2nd Course _____ Grade _____

3rd Course _____ Grade _____

4th Course _____ Grade _____

Name of High School _____

Location of High School _____
Town County State

Semester Status (FTE) _____ Curriculum _____ Major _____

Employment Experiences _____

Hobbies/Interests _____

Reading Preferences _____

Parental Education (check as appropriate)

Mother		Father	
_____ H.S.	_____ Graduate	_____ H.S.	_____ Graduate
_____ College	_____ Other _____	_____ College	_____ Other____

Parental Occupation (check as appropriate)

Mother	Father
_____ Clerical	_____ Clerical
_____ Industrial	_____ Industrial
_____ Professional	_____ Professional
_____ Other _____	_____ Other _____

I herewith allow the course instructor to use this information and/or information from my college files to conduct instructional research. All information will be held confidential and reports of this research will keep the indentity of individuals anonymous.

_____ _____
Signature date

APPENDIX F

TREATMENT SEQUENCE AND READING ASSIGNMENTS

TREATMENT SEQUENCE

Week	Lecture Topic	Contemporary Topics Lab	Standard Topics Lab
1	Introductions/ Basic Measurements	-	-
2	Science	Scientific Method	Analysis of an Experiment
3	Mechanics	Satellites and Missles	Velocity and Acceleration
4	Thermal Energy	Solar Heat	Specific Heat
5	Static and Current Electricity	Wind Energy	Motor/Generator Effects
6	Wave Properties	Lasers	Ripple Tank
7	Wave Intensity	Noise Pollution	Photometry
8	Nuclear Reactions: Fusion and Fission	Nuclear Energy	Radioactivity

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Kutztown, Pennsylvania

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Phy 10L - Standard Topics

This semester students will be expected to prepare reading reports for the experiments of the first unit (Physics Topics). The following is a table of the experiments and the appropriate reading. The student is expected to read our text plus one of the reference texts. The reference texts will be on reserve in the Rohrbach Library.

January 17-19
(a) Explanation of Grading System
(b) Explanation of Laboratory Series
(c) Assignment of Reference Text Readings

Physics Experiment Schedule	Topic	Reference Texts Chapters					
		Buecke	Cable et al	Reilly-Vander Pyl	CRM Books	Payne-Falls	Holcomb-Morrison
Jan. 24-26	Analysis of an Experiment	x	1	1	x	1	x
Jan. 31 - Feb. 2	Velocity and Acceleration	3	3	3	7	3	5
Feb. 7-9	Electricity and Magnetism	7	7	6	25	7	11
Feb. 14-16	Specific Heat	5	10	4	x	4	12
Feb. 21-23	Wave Properties	8	25	7	26	6	9
Feb. 28 - March 2	Wave Intensity	x	26	8	2	x	x
March 7-9	Radioactivity	11	23	15	28	10	x

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Physical Science Dept. - Spring 1978

PHY 10L - CONTEMPORARY TOPICS

This semester the laboratory units for Physics and Chemistry will use different instructional methods. The Physics unit will be alternating periods of discussion and experiments based on readings of contemporary scientific articles. The topics of the Physics unit will include (1) Scientific Method(s) (2) Satellites and Missiles (3) Solar Energy (4) Mechanical/Electrical Energy (5) Lasers (6) Sound and (7) Nuclear Energy.

Meeting # 1
(a) Explanation of Grading System
(b) Explanation of Laboratory Series
(c) Assignment of Readings on Scientific Method(s)

Meeting # 2
(a) Discussion of Scientific Method(s) of Problem Solving
(b) Experiment 1: Analysis of a Physics Experiment
(c) Assignment of "Do at home experiment"
(d) Assignment of Readings on Satellites and Missiles

Meeting # 3
(a) Discussion of Satellites and Missiles Readings
(b) Experiment 1B: Analysis of a Falling Body
(c) Assignment of Readings on Solar Energy

Meeting # 4
(a) Discussion of Solar Energy Readings
(b) Experiment 2: Specific Heat of Solar Heating Materials
(c) Assignment of Readings on Mechanical/Electrical Energy

Meeting # 5
(a) Discussion of Mechanical/Electrical Energy
(b) Experiment 3: Motor/Generator Effect
(c) Assignment of Readings on Lasers

Meeting # 6
(a) Discussion of Readings on Lasers
(b) Experiment 4: Wave Properties

Meeting # 7
(a) Discussion of the various Readings on Sound
(b) Experiment 5: Wave Intensity
(c) Assignment of Readings on Nuclear Energy

Meeting # 8
(a) Discussion of the various Readings on Nuclear Science
(b) Experiment 6: Nuclear Science

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Kutztown, Pennsylvania

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PHY 10L - Readings on Scientific Method(s)

PART A - Required of all students *

1. "Marijuana at Work", The Sciences, Oct. 1975, p. 18-20.
2. "Letters to the Editor: Questioning the Jamaican Study" The Sciences, Nov. 1975, p. 3.
3. "Letters to the Editor: Science and Marijuana". The Sciences, Dec. 1975, p. 3.
4. "An Exchange on Marijuana", The Sciences, July/ August 1976, p. 26+.

PART B - Options - Select at least one

1. "An Unscientific Phenomenon: Fraud Grows in Laboratories", Science Digest, June 1977, p. 38-40.
2. "Behind the Mask of Objective Science" The Sciences, Nov./Dec. 1976, p. 17+.
3. (Substitute) article of student's preference.

* Duplicate copies of required readings available on reserve at Rohrbach Library.

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PHY 10L - Readings on Satellites and Missiles

(Twentieth Century Applications of Newton's Laws of Motion and Gravitation)

PART A - Required of all students *

1. "Cruise Missiles", Scientific American 236 (2): 20-29, February, 1977.

PART B - Options - Select at least two

1. "Appalachia's on the Beam", American Education, pp 21-24, May 1976.

2. "Whatever Happened to ... Satellites in Space", U.S. News and World Report, p. 69, Sept. 13, 1976
and
"A 'Frightening Problem' for the Soviets", U.S. News and World Report, p. 25, Feb. 2, 1976.

3. "Trident in Trouble: New Missile May Resemble Poseidon, After All", Science, pp 50-51, Jan. 9, 1976.

4. "Security Blankets of the Super" Bulletin of the Atomic Scientists, pp 19-20, November 1976.

5. "Soviet Killer Satellites: U.S. Ponders a Response", Science, pp 865-866, Sept. 3, 1976.

6. "Looking In On Us", Environment, pp 6-11, August-September, 1977.

* Duplicate copies of required readings available on reserve at Rohrbach Library.

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Kutztown, Pennsylvania

Physical Science Dept. - Spring 1978

PHY 10L - Readings on Solar Energy

PART A - Required of all students *

1. "Here Comes The Sun", Newsweek, pp 94-95, May 16, 1977.

2. "Solar Politics: Lame Duck Officials Initiate a Major New Study" Science 194: 1256-1260, Dec. 1976.

PART B - Options - Select at least two:

1. "Don't Rush to Solar Heat", Changing Times, August 1977, p. 8.

2. "Solar Heat Lights Up a New Industry", Business Week, May 16, 1977, p. 142.

3. "Israel Moves Toward a New Solar Society", Intellect, July, 1977, p. 5.

4. "Solar Energy Goes to Sea", The Sciences, May/June 1976, p. 27+.

5. (Substitute) article of student's preference.

* Duplicate copies of required readings available on reserve at Rohrbach Library.

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PHY 10L - Reading on Wind Energy

PART A - Required of all students *

1. "Wind Energy", Bulletin of Atomic Scientists, Sept. 1976, pp. 38-45.

PART B - Options - Select at least one

1. "Dependability of Wind Energy Generators with Short-Term Energy Storage", Science, Nov. 26, 1976, pp 935-937.

2. "Wind", Science Digest, pp 26-32, October, 1977.

3. "Energy - A Community Solar and Wind Energy System", Environment, March 19-7, p. 3-4.

* Duplicate copies of required readings available on reserve at Rohrbach Library.

KUTZTOWN STATE COLLEGE
Kutztown, Pennsylvania

Physical Science Dept. - Spring 1978

PHY 10L - Readings on Lasers

PART A - Required of all students *

1. "What is a Hologram? How Does It Float in Midair... And Is It Art?", Ms. pp 34, 35, and 39. December 1976.

2. "High - Energy Laser Weapons", Science News, pp 11-13, July 3, 1976.

PART B - Options - Select at least one

1. "White - Light Holograms", Scientific American, pp 80-95, October 1976.

2. "Forgotten Inventor Emerges from Epci Patent Battle With Claim to Laser", Science, pp 379-381.
and
"A Laser Patent That Upsets the Industry", Business Week, October 24, 1977.

3. (Substitute) article of student's preference.

* Duplicate copies of required readings available on reserve at Rohrbach Library.

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Kutztown, Pennsylvania

Physical Science Dept. - Spring 1978

PHY 10L - Readings on Sound

PART A - Required of all students *

1. "Noise", Horizon, September 1977, pp 66-69.

2. "How Loud Are Your Speakers", High Fidelity Magazine, June 1976, pp 44-49.

PART B - Options - Select at least one

1. "How Modern Life Can Damage Your Hearing", U.S. News and World Report, May 3, 1976, p 57-60.

2. "Noisy Silence: Infrasound Can Warn of Impending Diaster", Science Digest, May 1977, pp 27-28.

3. "Concord Sonic Booms as an Atmospheric Probe", Science, July 1, 1977, p 47-49.

4. (Substitute) article of student's preference.

* Duplicate copies of required readings available on reserve at Rohrbach Library.

KUTZTOWN STATE COLLEGE
Kutztown, Pennsylvania

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PHY 10L - Readings on Nuclear Energy

PART A - Required of all students *

1. "The Necessity of Fission Power", Scientific American, January 1976, pp 21-31.

PART B - Options - Select one from group 1 and one from group 2

Group 1

1. "An Acceptable Nuclear Future", The Sciences, December 1977, pp 18-23.
2. "Nuclear Energy - Risks x Benefits...." Science Digest, October 1977, pp 20-25.
3. "Why the Breeder Reactor is Inevitable", Fortune, September 1977, pp 123-130.

Group 2

1. "Nuclear Fusion's Promise Grows", Science Digest, July, 1977, pp 8-10.
2. "The Great Nuclear Fusion Race", Time, June 5, 1977, p 80-81.

* Duplicate copies of required readings available on reserve at Rohrbach Library.

VITA

Name: John Patrick Schellenberg

Birth Date: December 31, 1940

Birth Place: Allentown, Pennsylvania

Wife: Susan Tyler

Child: Joseph

Degrees:

Bachelor of Science (1962)
King's College
Wilkes-Barre, Pennsylvania

Master of Education (1964)
Temple University
Philadelphia, Pennsylvania

Master of Arts in Teaching (1967)
Duke University
Durham, North Carolina

Doctor of Education (1980)
The Pennsylvania State University
University Park, Pennsylvania

Professional Experience:

1962-1965	Science Teacher Norristown High School Norristown, Pennsylvania
1965-1966	Science Teacher Salisbury High School Allentown, Pennsylvania
1966-	Associate Professor of Physical Sciences
1972-	Director of Orientation and Special Services Kutztown State College Kutztown, Pennsylvania

Professional Organizations:

American Association for Higher Education (AAHE)

American Association of University Professors (AAUP)

Association of Pennsylvania State College and University Faculty (APSCUF)

National Orientation Directors Association (NODA)